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USAAVLABS TECHNICAL REPORT 67-48

ADVANCED LIFT FAN SYSTEM (LFX) PRELIMINARY DESIGN SPECIFICATION (U)

By

Harris C. True

December 1967

U. S. ARMY AVIATION MATERIEL LABORATORIES
FORT EUSTIS, VIRGINIA

CONTRACT DA 44-177-AMC-422(T)

GENERAL ELECTRIC COMPANY
FLIGHT PROPULSION DIVISION
CINCINNATI, OHIO

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(U) This report has been reviewed by the U. S. Army Aviation Materiel Laboratories and is considered to be technically sound. This preliminary design specification covers the requirements for mechanical and aerodynamic design, performance, and installation of an advanced lift fan demonstration.

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Task 1M121401D14415
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ADVANCED LIFT FAN SYSTEM (LFX) PRELIMINARY DESIGN SPECIFICATION (U)

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Harris C. True

Prepared by

General Electric Company
Flight Propulsion Division
Cincinnati, Ohio

for

U.S. ARMY AVIATION MATERIEL LABORATORIES
FORT EUSTIS, VIRGINIA

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(U) ABSTRACT

A Preliminary Design Specification for an advanced-technology lift fan V/STOL propulsion system is presented. Requirements for mechanical and aerodynamic design, performance, and installation are given. Design requirements are based on generalized aircraft installation requirements for a class of aircraft suitable to various mobility concepts.

(U) FOREWORD

The program was conducted during the period 20 May 1966 through 30 December 1966 under U.S. Army Aviation Materiel Laboratories Contract DA 44-177-AMC-422(T) by the Lift Fan Systems Operation of the General Electric Company's Advanced Technology and Demonstrator Programs Department. The Lift Fan Systems Operation has been engaged in active development of lift ιan V/STOL propulsion since 1958.

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(C) LFX DESIGN SPECIFICATION (U)

1. (C) SCOPE (U)

1.1 (U) Scope.- This preliminary design specification covers the requirements for mechanical and aerodynamic design, performance, and installation of an advanced lift fan demonstrator. The lift fan design is predicated on the use of a high energy gas generator representative of 1968 technology. Data presented herein are objectives and represent minimum performance levels except where otherwise noted.

The requirements contained in this specification are intended to serve as a basis for detail design and manufacture of the LFX wing fan demonstrator. These requirements are a result of the LFX studies and preliminary mechanical design performed to date and are not intended to constitute a commitment on the part of the General Electric Company. This document is also intended for use as a guide for a preliminary model specification for the LFX propulsion system and can be used as a basis for future studies and proposals.

1.2 (U) Classification.- The LFX lift fan is an advanced-technology fan system designed to be compatible with gas generator core engine technology typified by the GE J97/J1B turbojet. The LFX fan is typical of a class of lift fans which would be suitable for installation in a general-purpose V/STOL aircraft suited for surveillance, target data acquisition, close support, search and rescue missions, etc. The complete propulsion system for such an aircraft would include two gas generators with diverter valves, two wing fans, and one or more fuselage fans. The fan will provide aircraft control capability in fan flight mode by means of modulation of the fan scroll area and through exit louvers for vectoring of the fan efflux.

Although the LFX propulsion system is not designed for a specific aircraft installation, many of the design requirements are based on generalized aircraft installation requirements as recommended by various airframe manufacturers.

Performance data, weights, and dimensions are for one wing fan unless otherwise specifically stated.

1.3 (C) Basic turbojet gas generator (U).- The gas generator characteristics are based on General Electric concepts for advanced core engines. Weights and performance for the gas generator are compatible with those obtainable in the time period of 1968 to 1970 for production quantities. The selected gas generator characteristics feature the high specific energy exhaust gas which contributes to an efficient lift fan system. For the purposes of this document only, the engine shall be considered to include a control; a self-contained lubrication system; a fuel filtering system; an aircraft accessory power takeoff; an ignition system; and instrumentation for indicating rpm, oil temperature, and exhaust gas temperature. Basic gas generator features pertinent to the lift fan design are estimated at sea level standard day takeoff power to be:

$W_{5.1}$ = 68.2 lb/sec

$T_{5.1}$ = 1847°R

$P_{5.1}$ = 52.6 psia

Note: Engine characteristics included in this specification are not necessarily those of a specific existing engine. Engine features are included which are desirable for the lift fan system and compatible with airframe manufacturer's recommendations.

1.4 (U) Wing lift fan.- The LFX wing lift fan is sized to meet the mission requirements of VTOL aircraft with gross weights in the 20,000-pound class. Principal features of this fan are a maximum thrust-to-weight ratio of more than 20 to 1 for the fan alone, thrust modulation capability of 50 percent of the nominal thrust and integrated aircraft installation capability. The single-stage compressor has a tip-mounted turbine. Nominal fan compressor pressure ratio is 1.25 with a capability of 1.29 at maximum thrust conditions. The tip turbine scroll incorporates a variable area turbine nozzle to facilitate thrust modulation through turbine gas flow control. The installed diameter and thickness of the fan will permit installation between spars in a representative wing having a maximum thickness ratio equal to 9 percent of the chord. For the purposes of this document only, the wing lift fan shall be considered to include a rotor, a front frame with hard points for mounting fan inlet cover doors and actuators, a variable area scroll, a rear frame, exit louvers, and insulation. Instrumentation shall include an rpm sensor and a fan bearing temperature sensor.

1.5 (U) Fuselage lift fan.- Data are given for a fuselage or "pitch" control fan such as might be required in a typical three-fan two-engine aircraft installation. The performance, weights, and control data given for the fuselage fan are scaled from the wing lift fan. Desirable characteristics for the "pitch" fan include 100-percent thrust modulation (maximum thrust to zero thrust), maximum thrust to weight ratio in excess of 25 to 1, and integral aircraft installation features. Maximum fan compressor pressure ratio is 1.3. Thrust modulation capability is compatible with the pitch control requirements of a 20,000-pound gross weight VTOL aircraft having representative inertias. Other pitch control concepts such as two fuselage fans or a nose-mounted fuselage fan and a tail jet nozzle are also compatible with the LFX wing fan design.

1.6 (U) Diverter valve.- The LFX performance and weight estimates are compatible with a two-position double butterfly diverter valve. The diverter valve shall include integral mounts, actuating linkages, and insulation. Other diverter valve configurations are potentially feasible but would require analytical and test development to determine effects on installed performance.

2. (U) APPLICABLE DOCUMENTS

2.1 The following specifications and publications form a part of this design specification, except as modified herein:

Military Specification: MIL-E-5007C - Engines, Aircraft, Turbojet, General Specification for

Air Force-Navy Aeronautical Bulletin No. 343p - Specifications and Standards Applicable to Aircraft Engines and Propellers, Use of

2.2 The following documents shall be applicable to this design specification to the extent specified herein:

Military Specification: MIL-E-5009C - Engines, Aircraft, Turbojet, Qualification Tests for

Military Specification: MIL-J-5624F-1 - Jet Fuel, Grades JP-4 and JP-5

Military Report: USAAVLABS Technical Report 66-51 - Advanced Lift Fan System (LFX) Study

3. (C) REQUIREMENTS (U)

3.3 (U) Mockup.- A full-scale mockup of the left-hand LFX wing shall be prepared for installation in an aircraft. The mockup shall include scroll, mounts, exit louvers, and other fan features.

3.4 (U) Performance characteristics.- The ratings and curves shown are based on the terms and conditions defined in MIL-E-5007C, except as specifically modified or specified herein, and are based on the use of a gas generator fuel having a lower heating value of 18,400-Btu per pound and otherwise conforming to Specification MIL-J-5161E, Grade I, and a gas generator oil conforming to Specification MIL-L-7808E. These data indicate estimated levels of uninstalled performance for the propulsion system under atmospheric conditions. The gas generator performance does not include inlet losses, shaft power extraction, customer bleed air losses, or other installation losses. Flow leakage at the diverter valve is assumed to be 1 percent of the total flow in the fan mode. A fixed-area nozzle, trimmed to attain the rated exhaust gas temperature, is assumed for the jet-mode data. Lift fan mode of performance includes losses for the diverter valve crossover duct, ducting as shown in the preliminary installation drawing, scrolls, inlets, inlet covers, and exit louvers. No external effects, such as reingestion or ground effect, are included.

3.4.1 (U) Fuel.- The core engine shall function satisfactorily throughout its complete operating range for any steady-state and transient operating condition when using fuels conforming to and having any of the variations in characteristics permitted by MIL-J-5624F-1, Grade JP-4 and Grade JP-5. Engine specific fuel consumption and windmill starting limits given in this specification are based on the use of JP-4 fuel.

3.4.1.2 (U) Emergency fuel.- The core engine shall be capable of limited time operation at reduced power when using fuel conforming to MIL-G-5572C, Grade 115/145, after appropriate external fuel control adjustment.

3.4.3 (U) Estimates.- Estimated performance data and curves are shown in Figures 1 through 14 inclusive and in Table I.

3.4.3.1.2 (U) Performance correction curves.- Data for correcting the estimated performance outlined in paragraph 3.4.3 are presented in Figures 15 through 22 inclusive and in Table I.

These data are for use in correcting performance by the method outlined in paragraph 3.4.3.1.3. Use of these correction factors beyond the specified range is not recommended. Sequence of use is secondary; however, the use of a large number of corrections with large changes from the nominal is not recommended.

3.4.3.1.3 (C) Method for correcting estimated performance (U).- The following equations illustrate the use of the correction factors in 3.4.3.1.2 for use in correcting the estimated performance shown in 3.4.3:

(a) To correct core engine cruise thrust:

$$F_{NC} = F_N \left[\left(\frac{F_{NDV}}{F_N}\right) - \left(\frac{\%\Delta F_N}{\%\Delta \eta_r}\right) \left(\frac{\%\Delta \eta_r}{100}\right) - \left(\frac{\%\Delta F_N}{\%W_B}\right) \frac{\%W_B}{100} \right]$$

where

F_{NC}	= corrected value of core engine cruise thrust.
F_N	= value of core engine cruise thrust, from Figures 1 through 4.
(F_{NDV}/F_N)	= cruise thrust loss due to presence of diverter valve, from Figure 15.
$\left(\frac{\%\Delta F_N}{\%\Delta \eta_r}\right)$	= thrust change due to change in core engine inlet recovery η_r, from Figure 16.
$\%\Delta \eta_r$	= percent change from 100% in core engine inlet recovery.
$\left(\frac{\%\Delta F_N}{\%W_B}\right)$	= thrust change due to compressor bleed, from Figure 17.
$\%W_B$	= compressor bleed, as a percentage of core engine airflow.

Example 1: Find the corrected static cruise thrust at sea level standard day for 2% compressor bleed and 98% engine inlet recovery.

Solution: F_N = 5250 lb, from Figure 1.

(F_{NDV}/F_N) = 0.97, from Figure 15.

$\left(\frac{\%\Delta F_N}{\%\eta_r}\right)$ = 1.3, from Figure 16.

$\left(\frac{\%\Delta F_N}{\%W_B}\right)$ = 0.855, from Figure 17.

$\%W_B$ = 2.

$\%\Delta\eta_r$ = 2.

$$F_{NC} = 5250\left[(0.97) - (1.3)\left(\frac{2}{100}\right) - 0.855\left(\frac{2}{100}\right)\right] = 4866 \text{ lb.}$$

(b) To correct cruise fuel flow (SFC):

$$(SFC)_c = SFC\left[\left(\frac{F_N}{F_{NDV}}\right) + \left(\frac{\%\Delta SFC}{\%\Delta\eta_r}\right)\left(\frac{\%\Delta\eta_r}{100}\right) + \left(\frac{\%\Delta SFC}{\%W_B}\right)\left(\frac{\%W_B}{100}\right)\right]$$

where

$(SFC)_c$ = corrected value of SFC.

SFC = ratio of fuel flow, from Figures 5 to 8, to cruise thrust, from Figures 1 to 4.

$\left(\frac{F_N}{F_{NDV}}\right)$ = reciprocal of value read from Figure 15.

$\left(\frac{\%\Delta SFC}{\%\Delta\eta_r}\right)$ = SFC change due to change in engine inlet recovery, from Figure 16.

$\%\Delta\eta_r$ = percent change from 100% in engine inlet recovery.

$\left(\frac{\%\Delta SFC}{\%W_B}\right)$ = SFC change due to compressor bleed, from Figure 18.

$\%W_B$ = compressor bleed, as a percentage of engine airflow.

Example 2: Find the fuel flow and SFC at sea level static conditions for 98% engine inlet recovery and 2% compressor bleed.

Solution: Static thrust = 5250 lb, from Figure 1.

Fuel flow = 4652 lb/hr, from Figure 5.

SFC = 4652/5250 = 0.886.

$(\frac{\%\Delta SFC}{\%\Delta\eta_r})$ = 0.32, from Figure 16.

$(\frac{\%\Delta SFC}{\%W_B})$ = 1.40, from Figure 18.

$\%\Delta\eta_r$ = 2.

$\%W_B$ = 2.

$(SFC)_c = 0.886\ [(1/0.97) + (0.32)\ (\frac{2}{100}) + (1.4)\ (\frac{2}{100})]$

$= 0.886\ (1.031 + 0.0064 + 0.028) = 0.944.$

W_F = 0.944 x 4866 lb. thrust (from Example 1) = 4594 lb/hr.

(c) Takeoff fuel flow:

Fuel flow during takeoff, as a function of ambient temperature and altitude, can also be read directly from Figure 19.

(d) Roll control capability:

Roll control capability is shown in Figure 13. As flow is transferred between the wing fans, the lift of the fan receiving flow will increase and the lift of the fan losing flow will decrease at the rates shown by the dashed lines in Figure 13. The sum of these two lift figures is the total wing fan lift; it decreases slightly with flow transfer due to losses and compressibility effects. The difference between these two lift figures is the thrust available for aircraft roll control. The fans have the capability of ± 35% flow transfer, providing a roll control force equal to 50% of the nominal fan lift.

(e) Effect of change in lift fan nominal operating point:

If the full available roll control capability is not required, the fans may be operated at a higher nominal point. Figure 14 shows the change in fan speed, lift, pressure ratio, and arc of admission for changes in the nominal operating point. This figure is a graphical representation of the data of Table I.

(f) Corrections to fan lift for changes in core engine inlet recovery and compressor bleed:

$$L_c = L\ [1 - (\frac{\%\Delta L}{\%\Delta\eta_r})\ (\frac{\%\Delta\eta_r}{100}) + (\frac{\%\Delta L}{\%W_B})\ (\frac{\%W_B}{100})]$$

where

L_c = corrected fan lift, lb.

L = fan lift.

$(\frac{\%\Delta L}{\%\Delta \eta})_r$ = correction to lift for core engine inlet recovery, from Figure 21.

$(\frac{\%\Delta L}{\%W})_B$ = correction to lift for compressor bleed, from Figure 22.

$\%W_B$ = core engine compressor bleed, as a percentage of core engine airflow.

Example 3: Find the corrected fan lift for a sea level standard day for 2% compressor bleed and 98% core engine inlet recovery.

Solution: L = 10,750 lb nominal lift, from Table

$\%W_B$ = 2; $\%\Delta\eta_r$ = 2.

$(\frac{\%\Delta L}{\%\Delta \eta})_r$ = 1.12, from Figure 21.

$(\frac{\%\Delta L}{\%W})_B$ = -0.60, from Figure 22.

$L_c = 10{,}750\ [1 - (1.12)\ (\frac{2}{100}) + (-0.60)\ (\frac{2}{100})] = 10{,}380$ lb.

(g) Effect of ambient temperature and altitude on fan lift:

Figure 20 gives fan lift as a function of the ambient temperature and altitude.

(h) Fan vectored lift capability:

Horizontal thrust (F_H) and vertical thrust (F_V) are shown as fractions of total thrust (F) in Table II as functions of flight speed and exit louver angle. Three levels of fan inlet recovery are shown. Inlet ram recovery is defined as the percentage of flight dynamic pressure which is recovered as total pressure in the fan inlet:

$$P_{T\ inlet} = P_{T\ amb} + \eta_R\ (\tfrac{1}{2}\rho V_P^{\ 2})$$

where

η_R = fan inlet recovery factor.

$P_{T\ inlet}$ = fan inlet total pressure, psia.

$P_{T\ amb}$ = ambient pressure, psia.

$\frac{1}{2}\rho V_p^2$ = dynamic pressure based on forward flight speed, lb/ft^2.

For example, zero recovery provides ambient pressure at the fan inlet, while 100% recovery provides total ram pressure at the fan inlet.

3.4.3.3 (U) Electronic automatic machine performance presentation.- Performance presentation for use with electronic automatic machines will be furnished in the "LFX Customer Leck".

3.4.4 (U) Altitude-temperature limits for flight starting and operating.- The estimated engine turbojet-mode starting limits are shown in Figure 23. The turbojet-mode operating limits are shown in Figures 24 and 25.

3.4.4.1 (U) Sea level operating limits.- The engine shall function satisfactorily in the turbojet mode up to and including a ram pressure ratio of 1.89 at sea level standard conditions, up to and including a ram pressure ratio of 1.89 at -65°F, and up to and including a ram pressure ratio of 1.89 at 103°F ambient temperature.

3.4.4.2 (U) Flight starting limits.- The engine turbojet shall be capable of air starts within the limitations shown in Figure 26.

3.4.4.2.1 (U) Altitude-temperature-airspeed limits for lift-mode operation.- The estimated lift-mode operating limits curve is shown in Figure 27.

3.4.4.4 (C) Absolute altitude (U).- The absolute altitude of the turbojet engine shall not be less than 60,000 feet at a 1.8 ram pressure ratio.

3.4.5 (U) Engine windmilling capability.- To be supplied later.

3.4.9 (U) Reverse thrust.- No reverse thrust mechanism is provided for turbojet-mode operation. Reverse thrust in the lift mode can be achieved through vectoring the fan exhaust forward.

3.4.10 (U) Thrust transients, turbojet mode.- During the selection of power lever positions in any sequence and at any rate, there shall be no objectionable overspeed, overtemperature, combustion instability, or compressor instability. For power lever movements of 0.5 second or less, the time required to safely accomplish 95 percent of the commanded thrust change shall not exceed the following value given with no customer accessory drive load, with no external compressor bleed and with an engine-furnished nozzle: from idle to military, 5 seconds at sea level standard day conditions.

3.4.14 (C) Measured gas temperature (U).- The maximum allowable measured turbojet exhaust gas temperature shall be 1415°F for continuous operation in either the turbojet mode or the fan mode.

3.4.15.1 (U) Engine starting.- The turbojet engine shall consistently make satisfactory ground and air starts. The engine shall be capable of air starting within the envelope shown in Figure 26. A satisfactory start shall be a start and acceleration from initiation of the starting sequence to the appropriate idle operating conditions using the procedure described in paragraph 3.32.2. Satisfactory ground starts shall be obtained within the time specified in Figure 23 when using a starter which meets the requirements of the 30-second start curve shown in Figure 26.

3.4.15.2 (U) Starting requirements.- Data for the determination of starting torque and speed requirements are shown in Figure 28. Data are based on the diverter valve being in the turbojet mode, unloaded accessory drive pads, and zero external bleed air extraction. The time required to accelerate from minimum starter cutout speed to idle speed shall not exceed 20 seconds.

3.4.15.3 (U) Restart time.- The minimum allowable time between ground starting attempts shall be 30 seconds.

3.7 (U) Drawings and diagrams.- The following General Electric Company drawings and diagrams form a part of this specification:

Preliminary System Installation - LFX (Figure 29)
LFX Preliminary Fan Design Configuration - 4013007-734, Sheets 1 and 2 (Figures 30 and 31)
LFX Preliminary Wing Fan Installation - 4013007-739 (Figure 32)

3.11 (U) Electrical systems.-

3.11.1.1 (U) External electrical power.- Table III defines the estimated electrical power from external sources required by the LFX propulsion system. The electrical equipment shall operate with power required as defined in MIL-STD-704.

3.11.1.2 (U) External hydraulic power.- Hydraulic power supplied from external sources will be required for the diverter valve actuation as follows:

System maximum pressure	3000 psi
Maximum demand, diverter valve	2.75 gpm
Continuous flow, diverter valve	0.20 gpm

3.11.1.3 (U) Exit louver actuation.- The exit louver system defined by Installation Drawing No. 4013007-739 requires a single actuator located at either the front or the rear of the wing fan rear frame main strut. Estimated maximum required force is 3600 pounds. Estimated required stroke is 3-1/2 inches.

3.11.1.4 (U) Fan cover door actuation.- The wing fan inlet cover doors, fuselage fan inlet cover doors, and exit shall be furnished by the airframe manufacturer. Actuation requirements have not been estimated.

3.11.1.5 (U) Diverter valve actuation.- The diverter valve shown in the LFX Installation Drawing requires a single linear hydraulic actuator. Actuator mount provisions shall be on the diverter body. The estimated maximum required stroke length is 4.0 inches with a maximum stroke time of 0.15 second. The estimated maximum force requirement is 3900 pounds. The diverter valve is a two-position valve and is not compatible with intermediate settings.

3.12 (U) Dry weight of complete system.- The dry weight of the complete LFX propulsion system, consisting of two turbojet engines, two diverter valves, two wing lift fans, and a fuselage pitch control fan arranged as shown in Installation Drawing, Figure 29, is estimated to be 2943 pounds. Table IV shows the estimated weights of major components. The weights shown include power transfer scrolls for the wing and fuselage fan and exhaust nozzles for the turbojet engines. Excluded from the dry weight are items normally associated with the installation characteristics and mission requirements of the airplane system. These exclusions are: oil tank, air-oil cooler, fuel heater, engine-mounted and -driven aircraft accessories and gearbox pads, fuel flowmeter, mount hardware not permanently affixed to the fans, engine or diverter valve, pneumatic ducting between the diverter valve exit flange and the fan scroll inlet flanges, and all hydraulic actuators.

3.12.2 (U) Weight of residual fluids.- The estimated weight of residual fluids remaining in the system after operation and drainage with the system in its normal attitude is 13 pounds.

3.14 (U) Flight maneuver forces.- The LFX system and its supports shall withstand, without permanent deformation, the conditions specified in Figure 33 while operating in the turbojet mode and the conditions specified in Figure 34 while operating in the fan mode.

3.14.3 (U) Mount reaction forces.- Using the sign convention of Figure 35, the mount reaction forces for the engine and fans are shown for unity load factors in Tables V through VII.

3.16 (C) Containment and rotor structural integrity (U).-

3.16.1 (C) Mass moment of inertia of rotating parts (U).- The effective mass moment of the turbojet rotating parts about the rotor axis is 20.6 in.-lb-sec^2.

3.16.1.1 (U) Moments of inertia.- Tables VIII and IX define the induced gyroscopic moments, polar inertia, and angular velocity associated with aircraft angular velocity.

3.17 (C) Engine vibration (U).- The maximum permissible engine case displacement and frequency caused by propulsion system vibration will be supplied at a later date. The presently estimated vibration displacement limits are as follows:

Turbojet (70 cps or higher)

Location	Maximum displacement
Any	3 mils steady state 4 mils transient

Wing Lift Fan

Location	Maximum displacement
Any	10 mils steady state 20 mils maximum instantaneous reading during transient

Fuselage Lift Fan

Location	Maximum displacement
Any	10 mils steady state 20 mils instantaneous reading during transient

3.18 (C) Compressor customer air bleed (U).- Compressor air bleed extraction shall be provided. The maximum permissible quantity exclusive of anti-icing which can be bled from each of the four mid-frame ports shall not exceed 2 percent of the engine airflow. There shall be no customer bleed during starting.

3.19 (C) Heat rejection and cooling (U).-

3.19.1 (U) Engine heat rejection.- An engine and propulsion system heat rejection and cooling requirements report summary shall be supplied later. The report shall include estimated cooling requirements, heat rejection rates, and skin temperatures for representative areas of the turbojet engine, wing lift fan, and fuselage lift fan.

3.19.2 (C) Engine component limiting temperatures (U).- The maximum allowable operating skin temperatures of turbojet engines are estimated to be as shown in Figure 36. The following list gives maximum operating temperatures for certain turbojet engine-mounted components:

Component	Temperature, °F (ambient)
Ignition generator	350
T_5 harness disconnect	350
Power pack	300
Tachometer-generator	285
Anti-icing valve	275
Junction box	300
All others	250

The LFX fan system does not require external cooling air during most operational modes. However, the fan installation must be vented.

3.19.2.1 (U) Insulation properties.- The scroll and rear frame insulation of the LFX fan shall be of a non-wicking design having a maximum conductivity of 0.8 Btu/hr/ft^2/in./°F at a mean insulation temperature of 900°F. Estimated insulation thickness is 1/2 inch.

3.20 (U) Infrared radiation.- No specific provisions for the suppression of infrared radiation have been made in either the turbojet or the lift fan engines. Infrared radiation emission patterns can be estimated at a later date.

3.21 (U) Engine air inlet.-

3.21.1 (U) Inlet protection.- No provisions shall be made for air inlet screens as an integral part of the turbojet engine, wing fan, or fuselage fan.

3.21.2 (U) Inlet air pressure variation.- The turbojet engine shall operate satisfactorily at all altitudes and flight speeds within the previously supplied engine flight envelope with variations in inlet total pressure as described in the following sections.

3.21.2.1 (C) Distortion (U).- The turbojet engine shall be designed to accept steady-state distortion levels (N_D) computed according to paragraph 3.21.2.2 and described graphically in Figure 37 within the following limits:

(a) The engine shall meet performance specified herein for steady-state inlet distortions not exceeding N_D = 0.10.

(b) At constant power settings, the engine shall withstand, without damage, steady-state inlet distortion not exceeding N_D = 0.20. Operation with N_D greater than 0.20 shall be limited to 10 seconds. Variations of the inlet total pressure not exceeding a maximum time rate of change of 30 percent per second are considered steady-state.

3.21.2.2 (U) Distortion index is defined by the expression

$$N_D = \frac{P_{t_{max}} - P_{t_{min}}}{P_t} \sqrt{\frac{2 A_L}{2 A_A}} \sqrt{\frac{\pi}{2}} \frac{\bar{P}_t - \bar{P}_{t_L}}{P_t - P_{t_{min}}}$$

where

A_A = area of compressor inlet annulus normal to the engine axis, including the 1/2-inch-high annulus areas at the inner and outer walls.

A_L = area of the continuous portion of the compressor inlet annulus wherein the measured pressures are less than the average P_t, including the continuous 1/2-inch-high area at the inner or outer wall, measured at the same axial plane as A_A.

A_E = equivalent low pressure area defined by the equation

$$A_E = A_L \frac{\pi}{2} \frac{(\bar{P}_t - \bar{P}_{t_L})}{(\bar{P}_t - P_{t_{min}})} .$$

P_t = any absolute total pressure in the plane of the compressor inlet, exclusive of pressure within 1/2 inch of the inner or outer wall.

$\bar{P}_t$ = average absolute total pressure area - weighted over the entire annulus at the plane of measurement.

$\bar{P}_{t_L}$ = average absolute total pressure area - weighted over the continuous area A_L where the total pressure P_t is less than the average $\bar{P}_t$.

$P_{t_{min}}$ = minimum total pressure within A_L.

$P_{t_{max}}$ = maximum total pressure within A_A.

3.21.2.3 (U) Graphical representation.- The distortion index can be expressed as

$$N_D = \frac{P_{t_{min}} - P_{t_{max}}}{\bar{P}_t} \times \sqrt{\frac{2 A_E}{A_A}}$$

where the ratio A_E/A_A is designated the area ratio of distortion. For values of A_E/A_A greater than 0.5, the maximum distortion is defined as the value at A_E/A_A = 0.5. Figure 37 shows this relationship graphically where lines of constant N_D are shown in terms of the maximum measured distortion and the area ratio of distortion.

3.21.2.4 (U) Inlet air pressure variation - lift fan.- The lift fan air inlet distortion compatibility shall not be less than that of the turbojet engine. Estimated limit values will be furnished at a later date.

3.21.3 (C) Allowable inlet connection stresses (U).-

3.21.3.1 (C) Turbojet inlet duct attachment (U).- The maximum allowable loads on the engine front frame flange due to loads transmitted by the air inlet duct shall not exceed the following:

(a) Moment - 5900 in.-lb
(b) Shear - 650 lb
(c) Uniform axial force - 2000 lb

3.21.3.2 (C) Turbojet inlet nose fairing (U).- The maximum allowable load on the engine front frame nose fairing flange due to loads transmitted by the nose fairing shall not exceed the following:

(a) Moment - 200 in.-lb
(b) Shear - 20 lb
(c) Uniform axial force - 75 lb

3.21.3.3 (U) Lift fan inlet.- The airframe/lift fan inlet bellmouth connection shall be of a flexible type incapable of transmitting airframe loads to the fan front frame.

3.22 (U) Anti-icing.-

3.22.1 (U) Type of anti-icing.- Anti-icing of the turbojet inlet guide vanes will be cockpit controlled, noncontinuous. The anti-icing valve shall be a combination manual "on-off" and temperature regulating valve. The electrical power requirements are specified in paragraph 3.11.1.1. Anti-icing air may be used up to the maximum flight speeds defined in Figure 38.

3.27 (U) Fire protection.-

3.27.1 (U) Fire shield attachment.- A fire shield attachment shall not be provided for the turbojet engine.

3.29 (U) Exhaust system.-

3.29.1.1 (U) Allowable diverter valve exhaust connection stresses.- The diverter valve axial (turbojet mode) and diverted (lift mode) duct attachment shall be of the quick-disconnect type. Duct attachments should be sufficiently flexible so that minimum airframe and ducting loads are transmitted to the diverter valve. Maximum acceptable loads shall be as follows:

	Axial Flange	Diverted Flange
Shear, lb	500	200
Axial Uniform Force, lb	2,000	500
Moment, in.-lb	16,000	2,400
Torque, in.-lb	6,000	2,600

3.29.1.2 (U) Allowable lift fan scroll duct connection stresses.- The wing and fuselage lift fan scroll duct attachment shall be of the quick-disconnect type. Maximum loads at the flexible connection shall be as follows:

Shear, lb	350
Moment, in.-lb	2,400
Axial Uniform Force, lb	700

3.29.1.3 (U) Lift fan exhaust connection stresses.- Exhaust connections for the lift fan shall be of a type which does not transmit airframe loads to the fan rear frame. No provisions shall be made for direct attachment of an exhaust duct to the LFX fan.

3.29.2 (U) Exhaust nozzle.- The exhaust nozzle shall be a fixed-area, converging nozzle. Provisions shall be made for adjustment of exhaust nozzle area to permit trimming the turbojet engine for rated power.

3.30 (U) Lubricating system.- The oil reservoir for the turbojet engine shall be furnished as optional equipment. The lubricating system for the lift fan shall be of the self-contained grease-packed type.

3.30.5.1 (C) Inlet pressure (U).- The turbojet engine lubricating system shall adequately lubricate the engine when oil containing 10 percent aeration by volume is supplied to the engine oil inlet at a pressure of 8 inches of mercury absolute.

3.30.5.2 (U) Scavenging system.- The turbojet scavenging system shall adequately scavenge the engine under ground operating conditions and under all flight conditions specified in section 3.4.6. Back pressure on the scavenging system shall not exceed 40 psig between maximum and 60 percent normal rated speed.

3.30.6 (U) Oil pressure and temperature.- The operating oil pressure at normal rated thrust shall be at 135°F oil temperature. The oil pressure indicator required for cockpit indication shall be 0-100 psi. The lube system shall have a pressure relief valve to prevent oil pressure from exceeding 400 psig. The engine shall not provide for cockpit indication of oil temperature.

3.31 (C) Fuel system (U).-

3.31.1.1 (C) Performance with assistance from airplane boost pump (U).- The engine fuel system shall supply the required amount of fuel at the required pressures for operation of the engine throughout its complete operating range, including starting with the following conditions at the fuel inlet connection of the engine:

(a) Fuel temperature - from a minimum of -65°F (MIL-J-56241-1, JP-4) or that temperature corresponding to a fuel viscosity of 12 centistokes (JP-5) to a maximum of 200°F.

(b) Fuel pressure - from true vapor pressure of the fuel plus 7.5 psi to 50 psig (relative to atmosphere), with a vapor/liquid ratio of zero.

3.31.1.2 (C) Performance with no assistance from airplane boost pump (U).- The engine fuel system shall supply the required amount of fuel at the required pressures for engine operation from sea level up to 20,000 feet altitude, including ground and air starting under the conditions specified below utilizing either JP-4 or JP-5 fuels.

(a) Compressor inlet ram pressure ratio varying linearly from 1.15 at sea level to 1.5 at 20,000 feet.

(b) Ambient air temperature at standard day conditions.

(c) Fuel temperature at the fuel inlet connection at a minimum of 110°F.

(d) Vapor/liquid ratio at the fuel inlet connection:

Starting - zero vapor/liquid ratio
Normal operation - zero to 0.45 vapor/liquid ratio

3.31.4 (U) Fluid leakage.- The fluid leakage from the engine overboard drain fittings shall not exceed 7.5 cc/minute.

3.31.5 (U) Fuel filters.- Protection against fuel filter icing shall be accomplished by fuel anti-icing additives. The engine primary fuel filters shall be protected against icing blockage through use of suitable integral bypass valves.

3.31.6 (U) Flowmeter.- The engine shall include provisions for installing a General Electric P/N 8TJ59GAS fuel flowmeter or equivalent in the fuel line between the fuel control and the pressurizing and drain valve.

3.32 (U) Control system, turbojet mode.- The turbojet engine control system shall be used for all turbojet-mode operation and shall include the following components:

(a) Main fuel control

(b) Main fuel pump

(c) Stator actuators

(d) Stator feedback

(e) Pressurizing and drain valve

During lift-mode operation, the turbojet throttle quadrant, controlling turbojet rpm directly, provides open-loop control of the lift fan thrust level.

3.32.1.1 (U) Fan control system performance.- The lift fan shall be capable of modulating thrust through a variable scroll turbine nozzle area for roll or pitch control and of vectoring thrust for aircraft horizontal acceleration or yaw control.

3.32.1.2 (U) Operating mode selection.- Selection of either the turbojet mode or the lift mode shall be performed by controlling the position of the diverter valve. The diverter valve controller shall be part of the aircraft control system and shall be two-position only.

3.32.4.1 (U) Control system adjustment - lift fan.- Means shall be provided to vary the nominal turbine nozzle scroll area through adjustment of the linkage leading to the variable area scroll actuator.

3.33 (U) Ignition system.- The turbojet ignition system shall be of the noncontinuous capacitor discharge type. Input voltage shall be 115 volts at 400 cps.

3.34 (C) Accessory drives (U).- A single power takeoff pad shall be provided for operation of remote aircraft accessories and for transmission of starting torque to the engine. Rotor to pad speed ratio is 1:1; at 100-percent rotor speed, the maximum continuous rating shall be 150 horsepower. For 5 percent of the operating life, the maximum rating shall be 223 horsepower.

3.43 (U) General additional information.-

3.43.1 (U) Maximum rotational speeds - lift fans.- The maximum continuous fan rotational speed shall be as follows:

Wing Lift Fan - 4681 rpm (115 percent)

It is anticipated that there shall be no requirement for automatic overspeed cutback controls for the wing or fuselage lift fan. Overspeed protection is afforded in the span between the design operating rpm of 100 percent and the maximum continuous allowable rpm of 115 percent.

3.43.3 (U) Lift fan instrumentation.- The LFX lift fan shall incorporate permanent flight safety, condition, and operating instrumentation. Instrumentation for flight safety shall include fan bearing thermocouples and vibration pickups. Condition instrumentation shall include a diverter valve position indicator and an exit louver position indicator. Operating instrumentation shall include fan rpm indication capable of rpm readout from 2 percent through 120 percent rpm range when matched to the appropriate readout device.

3.43.4 (U) Diverter valve leakage.- The estimated maximum leakage through the diverter valve gas seal into the inactive diverter valve leg is 1 percent of the total turbojet exhaust gas flow. The LFX fan shall have provisions for aspirated flow from an aircraft-supplied source of air at atmosphere or higher pressures.

3.43.5 (U) Scroll seal leakage.- During the fan mode of operation, the scroll seal leakage is estimated to be 0.2 percent of the total gas flow entering the scroll inlet. The LFX fan is estimated to have a pumping capability of 0.5 percent of the total turbine flow for secondary cooling airflow.

4. (U) QUALITY ASSURANCE PROVISIONS

4.3 (U) Qualification tests.- The qualification of the LFX propulsion system shall be predicated on the satisfactory completion of a Qualification Test based on requirements in MIL-E-5009C as modified and mutually agreed to by the General Electric Company and the procuring agency.

4.4 (U) PFRT.- The establishment of a preliminary flight rating for the LFX propulsion system shall be predicated on the satisfactory completion of tests in accordance with MIL-E-5009C as modified and mutually agreed to by the General Electric Company and the procuring agency.

TABLE I (C)
LIFT FAN POWER TRANSFER PERFORMANCE (U)

Operating Point	Minimum	Nominal	Maximum
Fan Pressure Ratio	1.167	1.24[illegible]	1.287
Fan Tip Speed, ft/sec	805	975	1090
Fan Speed, rpm	3358	4070	4558
Fan Speed, pct of nominal	82.5	100	112
Total Lift, lb	7420	10750	12750
Total Lift, pct of nominal	69	100	118.6
Arc of Admission, deg	156	250	360
Engine Flow, lb/sec	32.50	50.01	67.52
Engine Flow, pct of one engine	48.1	74.1	100

TABLE II (U)
EXIT LOUVER PERFORMANCE

Flight Speed (kts)	Louver Angle (deg)	Fan Inlet Ram Recovery 100%		50%		0%	
		F_H/F	F_V/F	F_H/F	F_V/F	F_H/F	F_V/F
0	0	0.000	1.000	0.000	1.000	0.000	1.000
	20	0.359	0.943	0.359	0.943	0.359	0.943
	30	0.491	0.856	0.491	0.856	0.491	0.856
	35	0.558	0.798	0.558	0.798	0.558	0.798
	45	0.654	0.654	0.654	0.654	0.654	0.654
100	0	-0.260	1.058	-0.270	1.039	-0.285	1.020
	20	-0.077	1.000	-0.096	0.981	-0.087	0.960
	30	0.260	0.914	0.250	0.895	0.241	0.885
	35	0.339	0.856	0.327	0.838	0.308	0.827
	45	0.462	0.702	0.448	0.693	0.423	0.674
150	0	-0.395	1.125	-0.406	1.077	-0.418	1.029
	20	-0.010	1.068	-0.024	1.010	-0.039	0.981
	30	0.166	0.972	0.144	0.933	0.125	0.895
	35	0.241	0.914	0.221	0.875	0.202	0.827
	45	0.375	0.750	0.356	0.720	0.337	0.683

TABLE III (U)
EXTERNAL ELECTRIC POWER REQUIREMENTS, LFX SYSTEM

Component	Voltage (VAC)	Frequency (cps)	Power (VA)
Ignition Generator	115	400	300
Anti-Icing Valve	115	400	300
Fuel Flowmeter*	115	400	15
Oil Pressure Transducer	24-28	380-420	Negligible
Fan RPM Sensors	28	-	Negligible
Exit Louver Position Transmitter	28	400	Negligible
Diverter Valve Position Indicator	28	400	Negligible

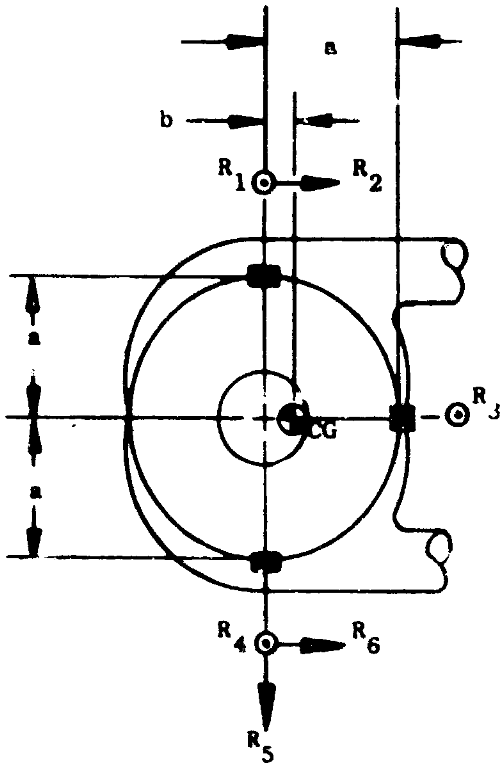
*Not engine-furnished

TABLE IV (C)
WEIGHT SUMMARY (U)

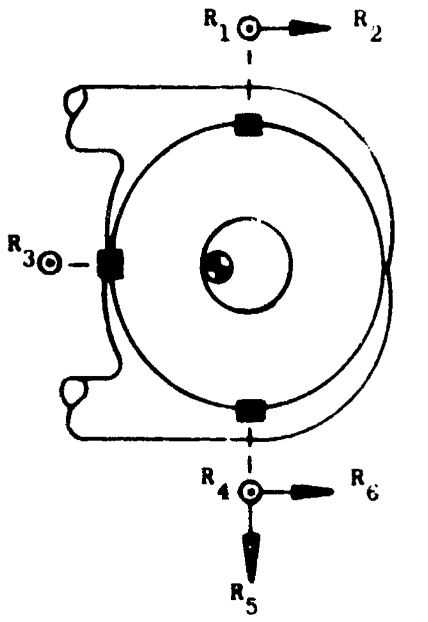
	Weight (lb)
Wing Fan Group	
Rotor	
Front frame, including bellmouth inlet and provisions for mounting wing fan closure doors	
Rear frame, including exit louvers but no actuator or exit louver mounts	
Scroll, with power transfer, no actuator	
Insulation	
Total	570
Fuselage Fan Group	
Rotor	
Front frame, no bellmouth	
Rear frame, no exit louvers	
Scroll, with power transfer, no actuator	
Insulation	
Total	277
Turbojet-Diverter Valve Group	763
Total Propulsion System per Aircraft	
2 engines	1526
2 wing fans	1140
1 pitch fan	277
Total	2943

TABLE V (U)
WING LIFT FAN MOUNT LOADS

Applied Force and Moment		Wing Fan Mount Loads					
		R_1	R_2	R_3	R_4	R_5	R_6
Aft force	F_A	-	$\pm bF_A/2a$	-	-	$-F_A$	$\mp bF_A/2a$
Side force	F_S	-	$-F_S/2$	-	-	-	$-F_S/2$
Vertical force	F_V	$\frac{b-a}{2a} F_V$	-	$-bF_V/a$	$\frac{b-a}{2a} F_V$	-	-
Pitch moment	M_P	$-M_P/2a$	-	-	$M_P/2a$	-	-
Roll moment	M_R	$\pm M_R/2a$	-	$\mp M_R/a$	$\pm M_R/2a$	-	-
Yaw moment	M_Y	-	$-M_Y/2a$	-	-	-	$M_Y/2a$



Left-Hand Wing Lift Fan



Right-Hand Wing Lift Fan

TABLE VI (U)
FUSELAGE LIFT FAN MOUNT LOADS

Applied Force and Moment		Fuselage Fan Mount Loads					
		R_1	R_2	R_3	R_4	R_5	R_6
Aft force	F_A	-	-	$-F_A$	-	-	-
Side force	F_S	-	$-F_S$	$\frac{a-b}{a} F_S$	-	$\frac{b-a}{a} F_S$	-
Vertical force	F_V	$-bF_V/a$	-	-	$\frac{b-a}{2a} F_V$	-	$\frac{b-a}{2a} F_V$
Pitch moment	M_P	$\pm M_P/a$	-	-	$\mp M_P/2a$	-	$\mp M_P/2a$
Roll moment	M_R	-	-	-	$M_R/2a$	-	$-M_R/2a$
Yaw moment	M_Y	-	-	$\pm M_Y/a$	-	$\mp M_Y/a$	-

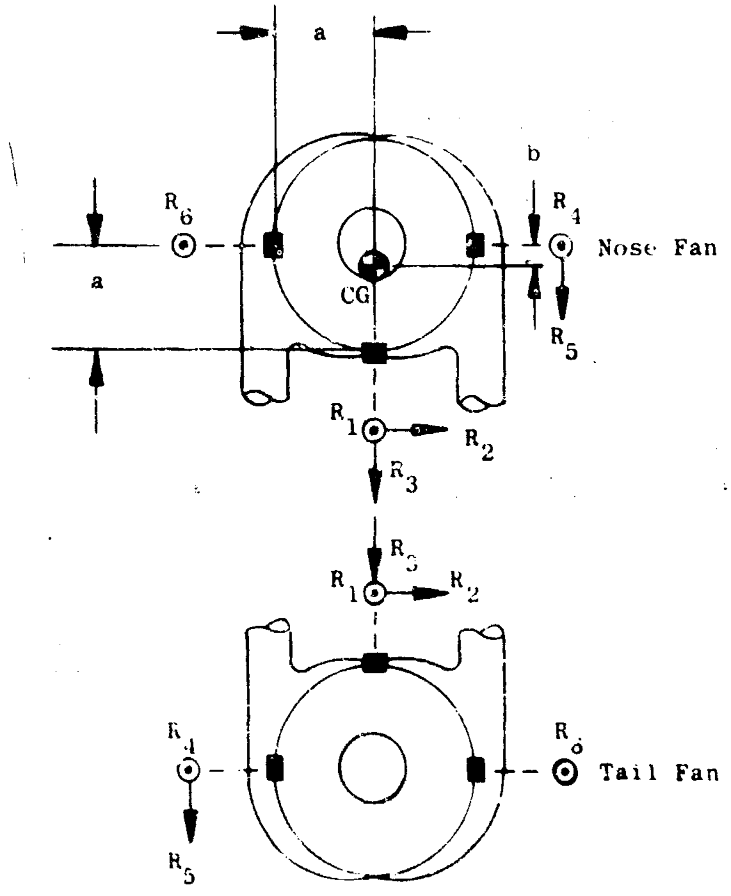
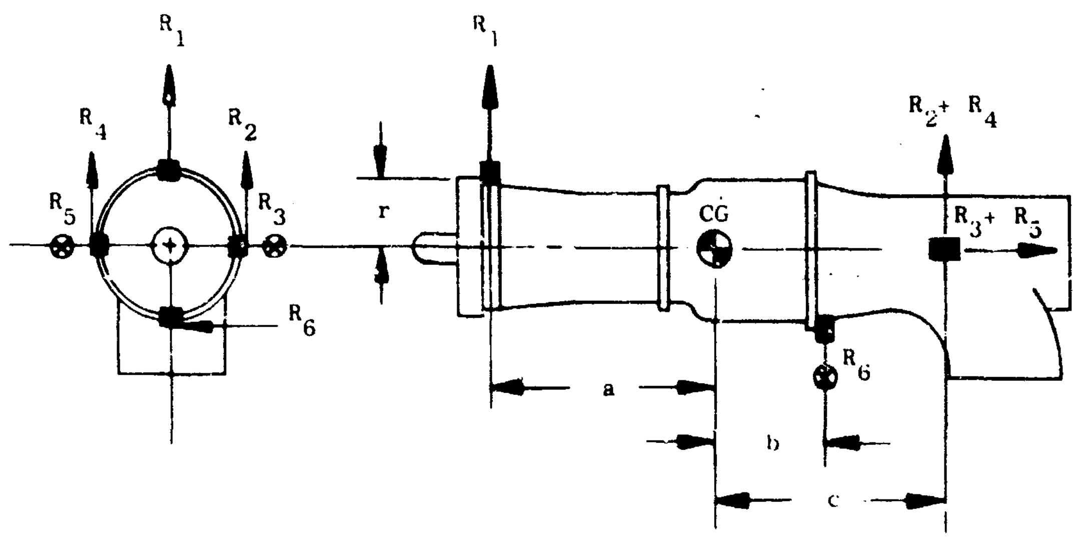


TABLE VII (U)

ENGINE MOUNT LOADS

Applied Force and Moment		Engine Mount Loads					
		R_1	R_2	R_3	R_4	R_5	R_6
Aft force	F_A	-	-	$-F_A/2$	-	$-F_A/2$	-
Side force	F_S	-	$-F_S/2$	$bF_S/2r$	$F_S/2$	$-bF_S/2r$	$-F_S$
Vertical force	F_V	$\frac{-cF_V}{a+c}$	$-\frac{1}{2}\frac{aF_V}{a+c}$	-	$-\frac{1}{2}\frac{aF_V}{a+c}$	-	-
Pitch moment	M_P	$\frac{-M_P}{a+c}$	$\frac{1}{2}\frac{M_P}{a+c}$	-	$\frac{1}{2}\frac{M_P}{a+c}$	-	-
Roll moment	M_R	-	$\frac{-M_R}{2r}$	-	$M_R/2r$	-	-
Yaw moment	M_Y	-	-	$M_Y/2r$	-	$-M_Y/2r$	-



Front View

Side View

TABLE VIII (C)
GYROSCOPIC MOMENTS (U)

Aircraft Angular Velocity	Induced Gyroscopic Moments			
	Engines	Wing Lift Fans Left	Wing Lift Fans Right	Fuselage Lift Fan
+pitch	+yaw	-roll	+roll	-roll
+roll	-	+pitch	-pitch	+pitch
+yaw	-pitch	-	-	-

TABLE IX (U)
SPEEDS AND POLAR INERTIAS

Component	Polar Inertia ($in.-lb-sec^2$)	Angular Velocity, Maximum Power (rpm)
Wing Lift Fan	146.2	4,558
Fuselage Lift Fan	18.6	6,750
Core Engine	20.6	13,650

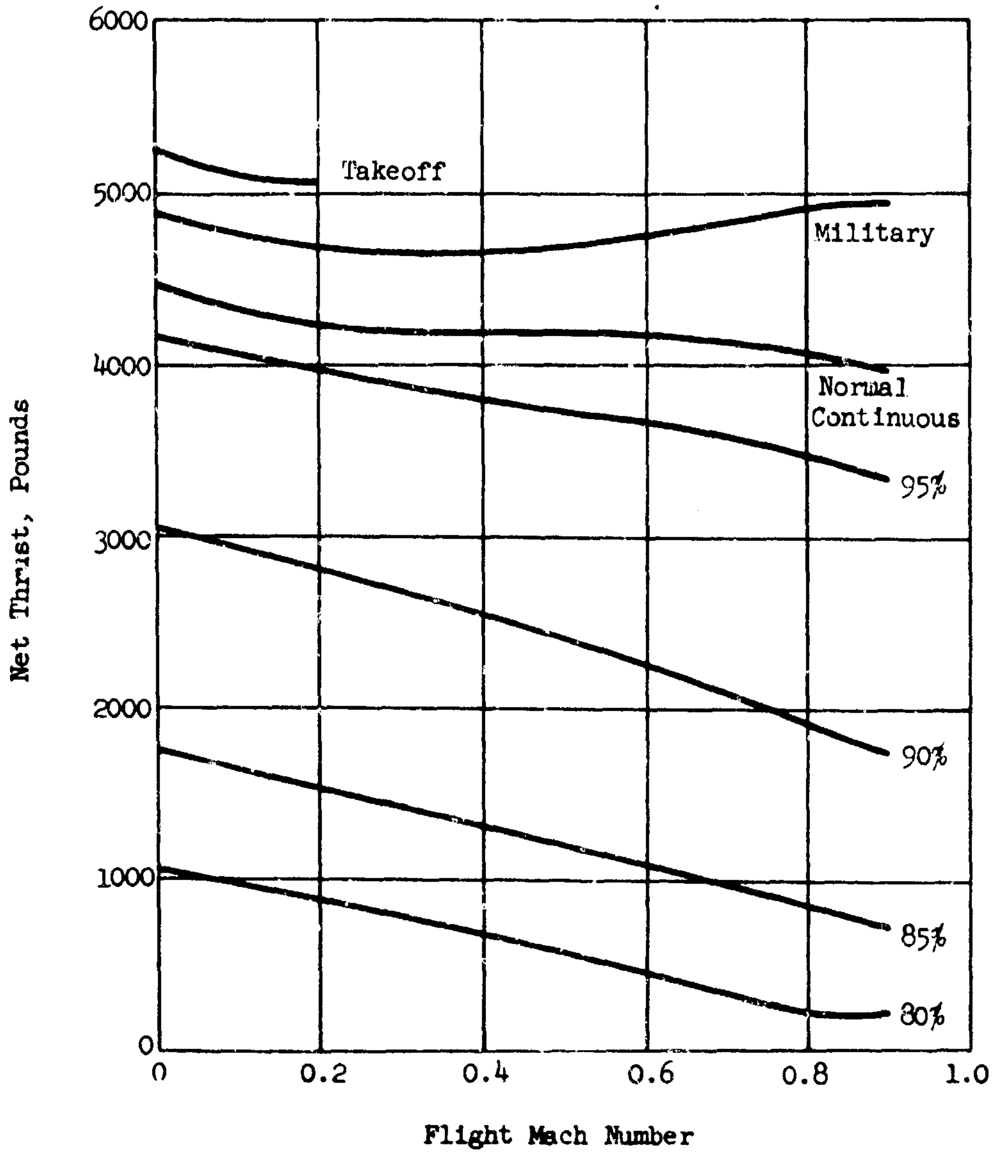


Figure 1. (C) J97/J1B Core Engine Turbojet Net Thrust Versus Flight Mach Number at an Altitude of Sea Level. (U)

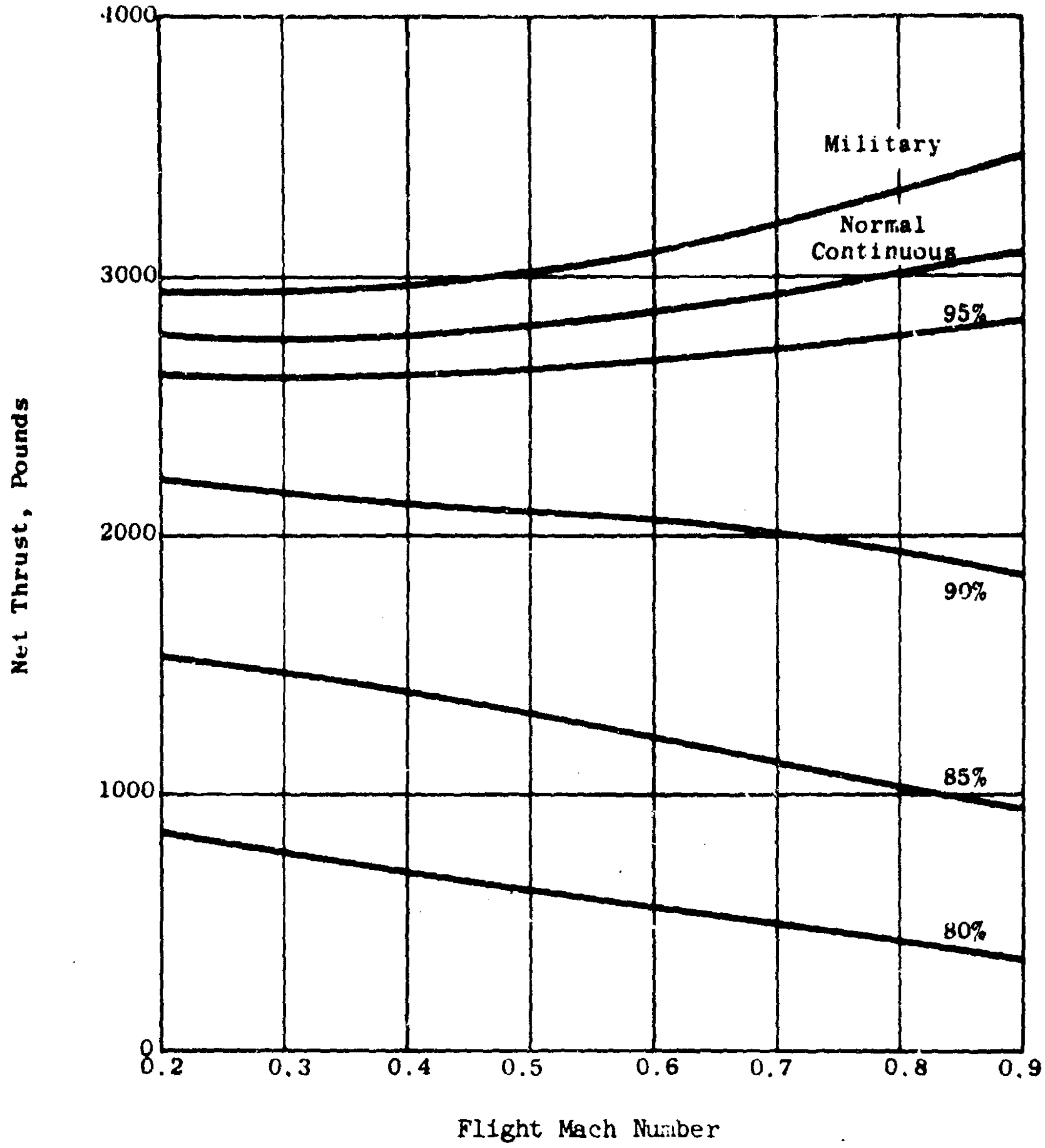


Figure 2. (C) J97/J1B Core Engine Turbojet Net Thrust Versus Flight Mach Number at an Altitude of 15,000 Feet. (U)

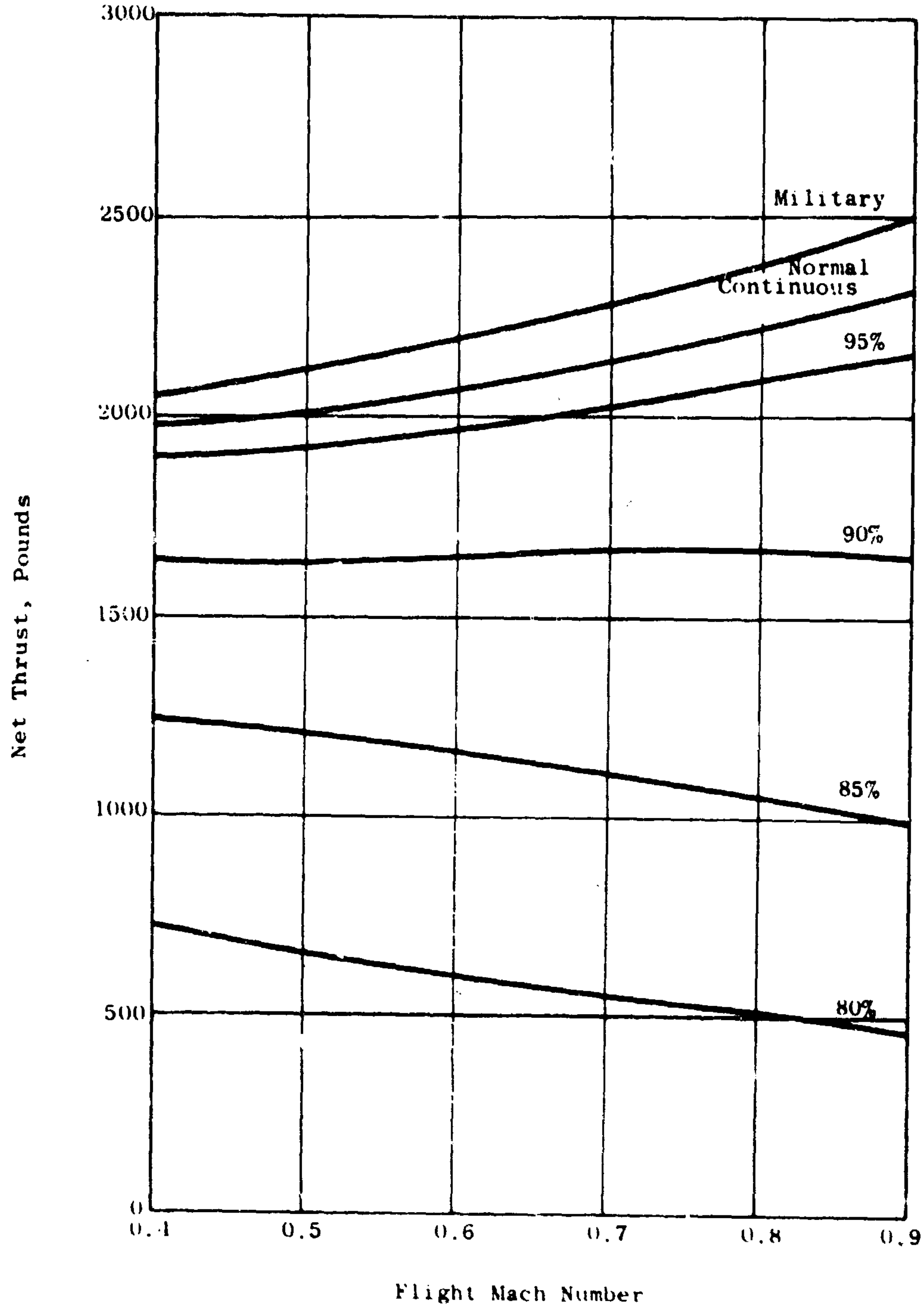


Figure 3. (C) J97/J1B Core Engine Turbojet Net Thrust Versus Flight Mach Number at an Altitude of 25,000 Feet. (U)

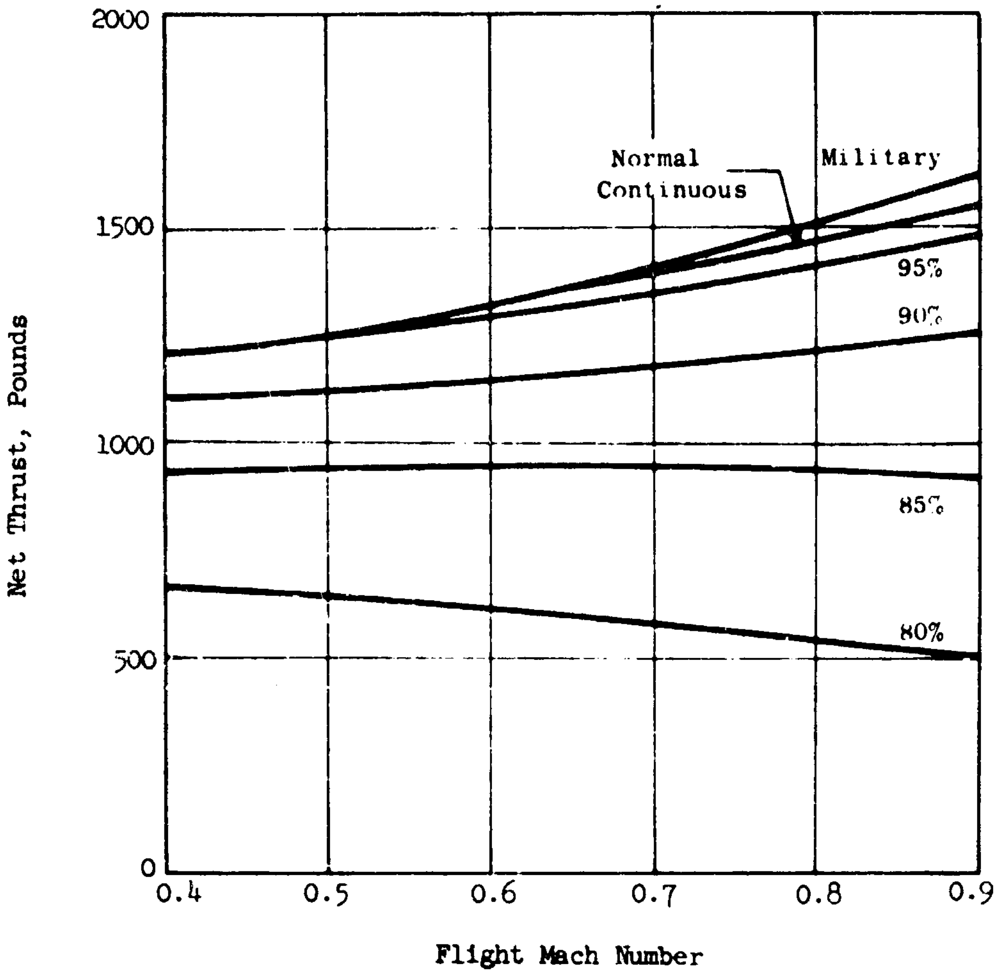


Figure 4. (C) J97/J1B Core Engine Turbojet Net Thrust Versus Flight Mach Number at an Altitude of 36,089 Feet. (U)

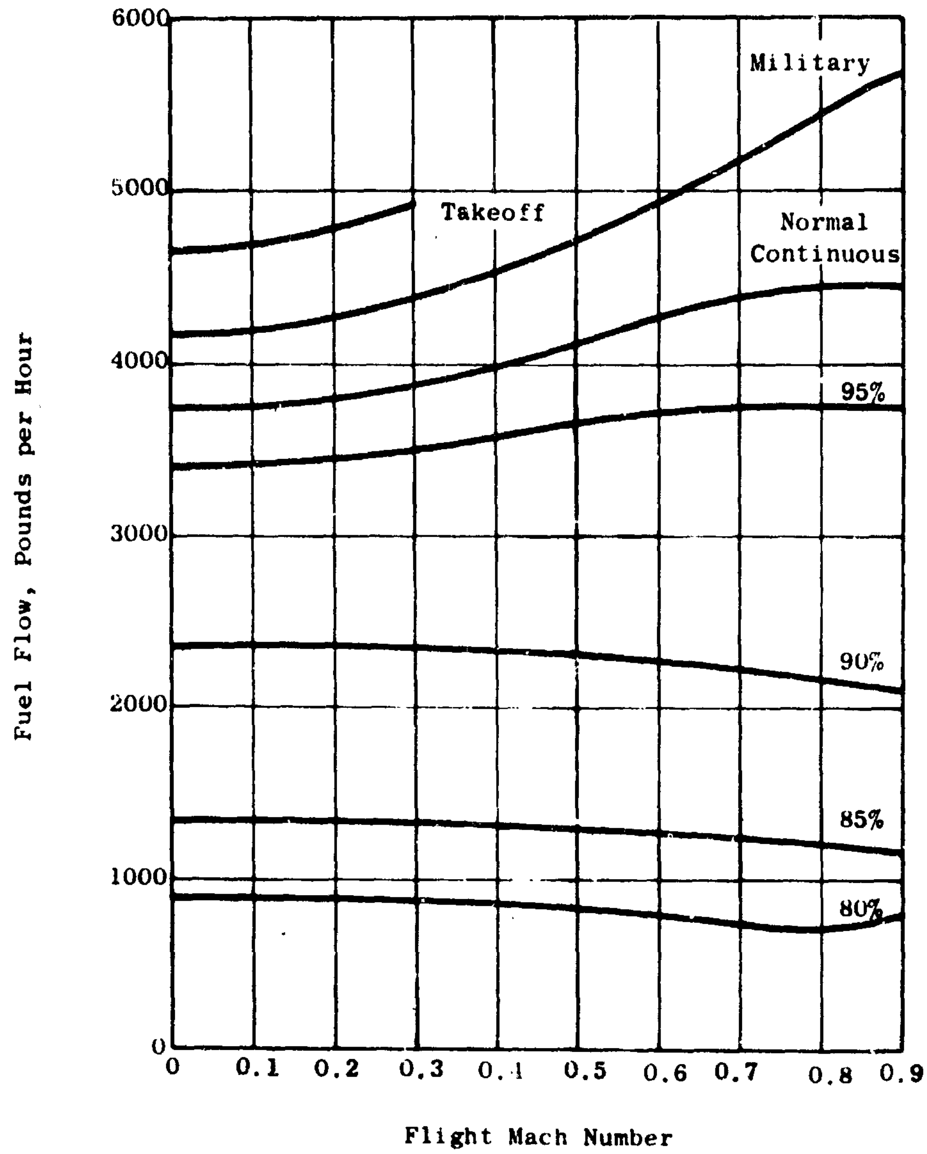


Figure 5. (C) J97/J1B Core Engine Fuel Flow Versus Flight Mach Number for One Core Engine at an Altitude of Sea Level. (U)

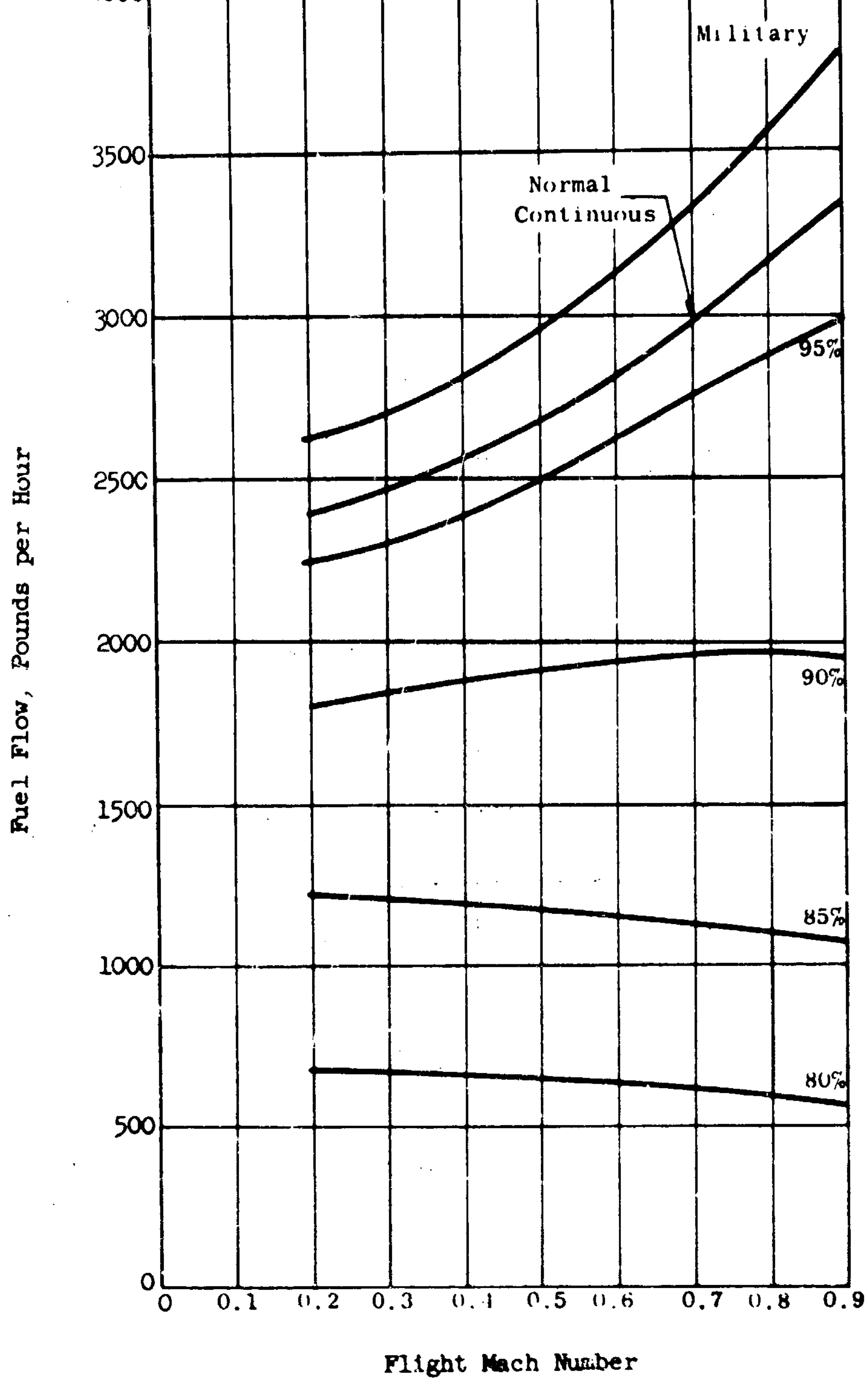


Figure 6. (C) J97/J1B Core Engine Fuel Flow Versus Flight Mach Number for One Core Engine at an Altitude of 15,000 Feet. (U)

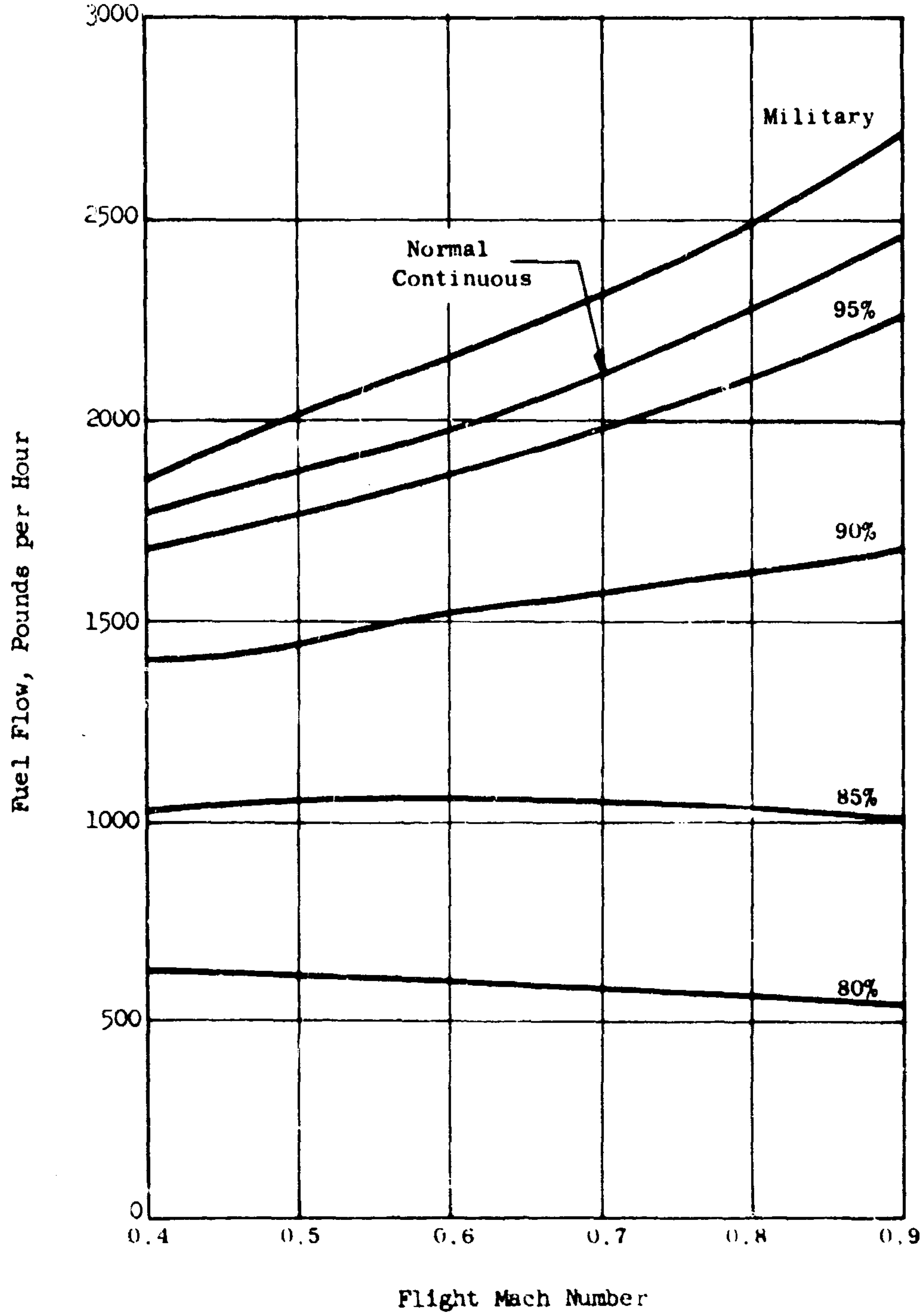


Figure 7. (C) J97/J1B Core Engine Fuel Flow Versus Flight Mach Number for One Core Engine at an Altitude of 25,000 Feet. (U)

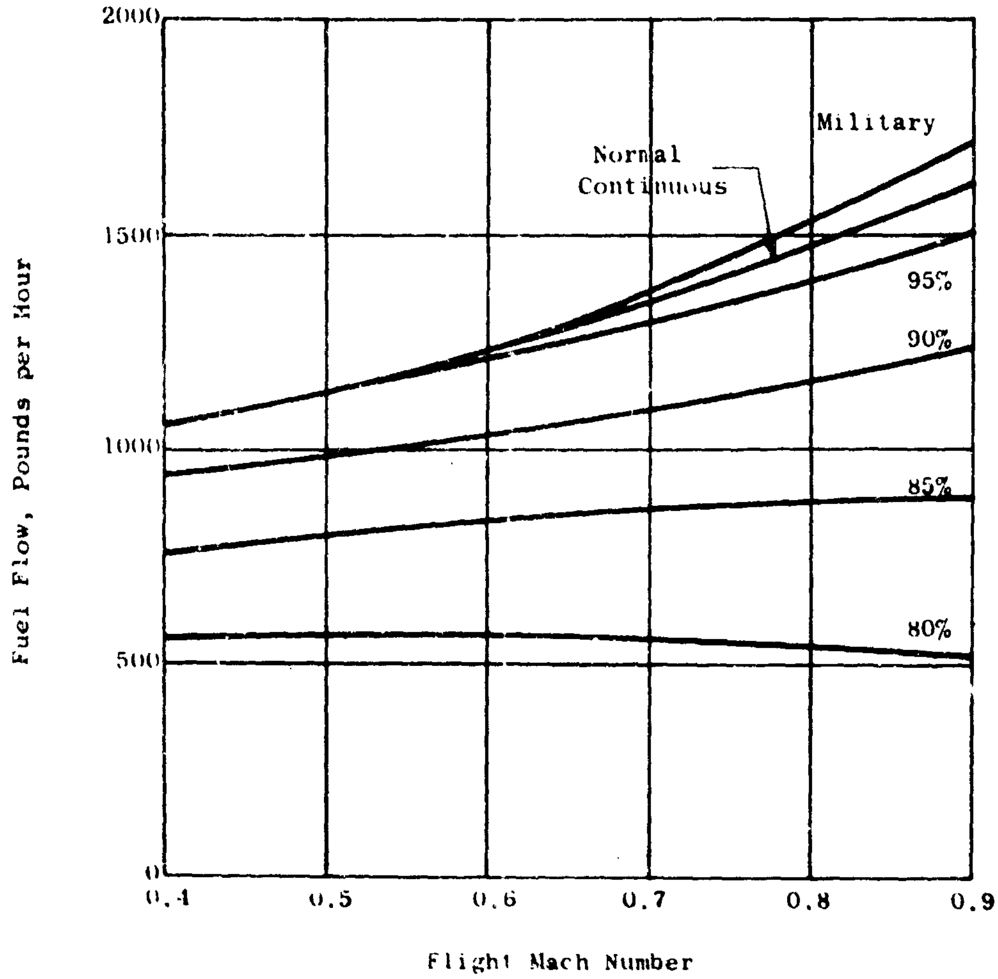


Figure 8. (C) J97/J1B Core Engine Fuel Flow Versus Flight Mach Number for One Core Engine at an Altitude of 36,089 Feet. (U)

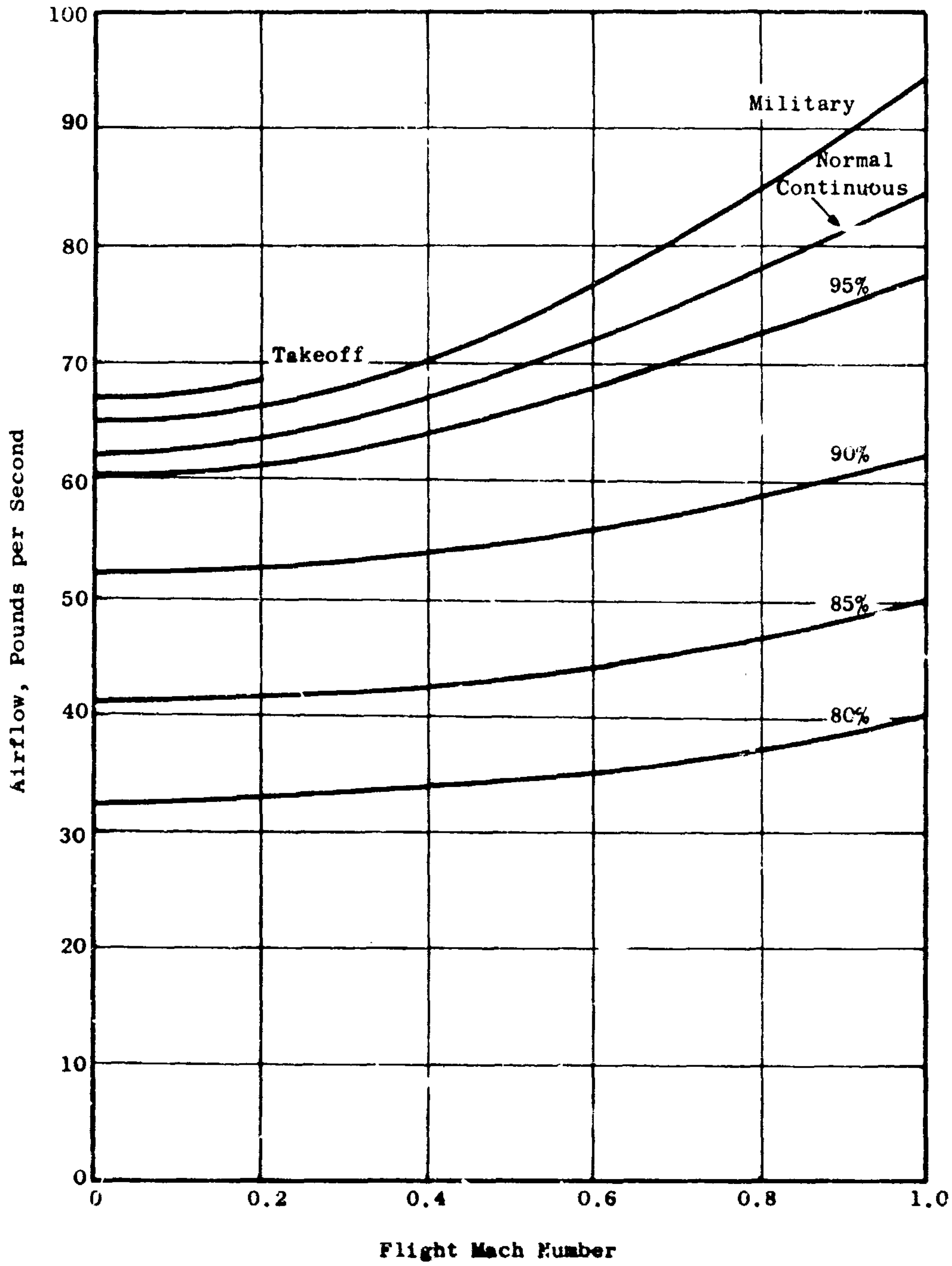


Figure 9. (C) J97/J1B Core Engine Airflow Versus Flight Mach Number at an Altitude of Sea Level. (U)

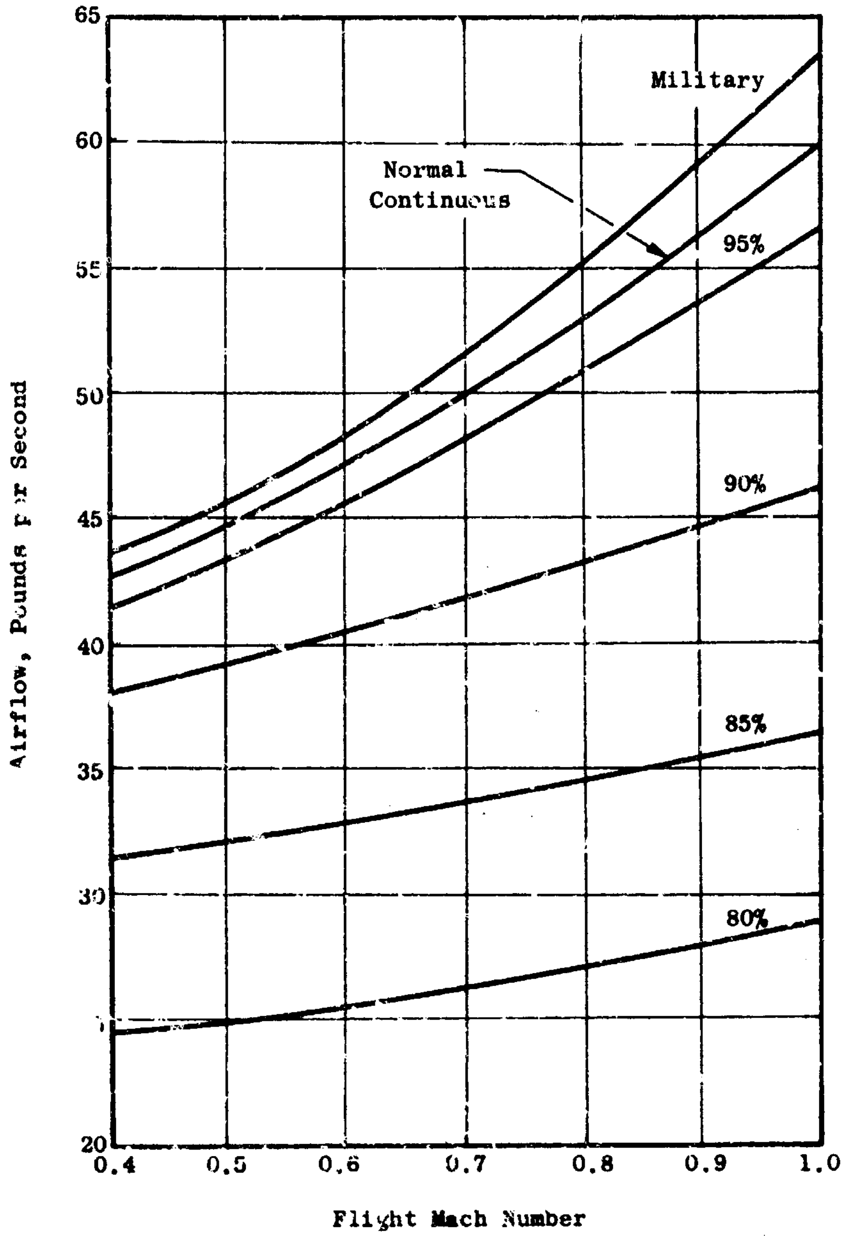


Figure 10. (C) J97/J1B Core Engine Airflow Versus Flight Mach Number at an Altitude of 15,000 Feet. (U)

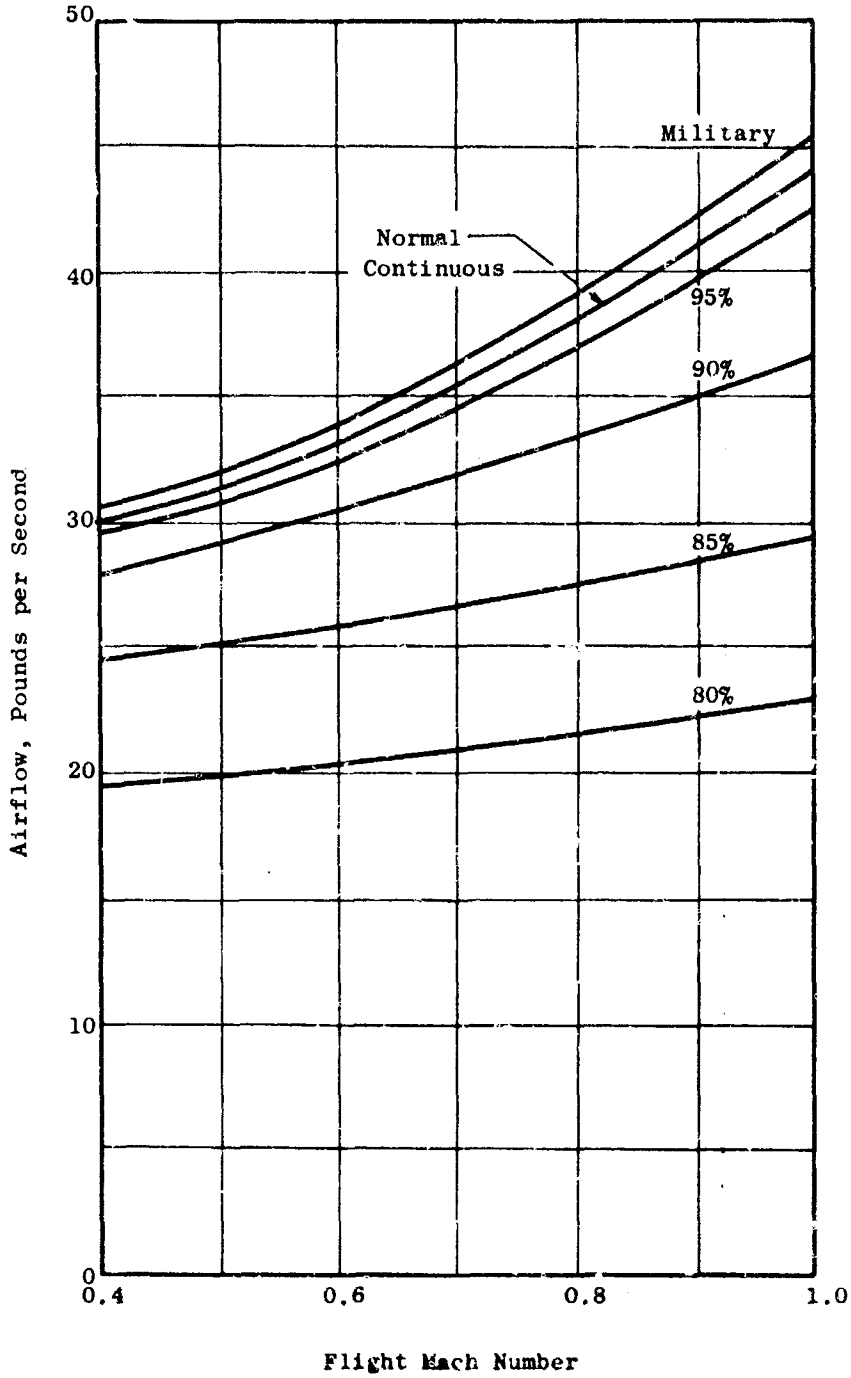


Figure 11. (C) J97/J1B Core Engine Airflow Versus Flight Mach Number at an Altitude of 25,000 Feet. (U)

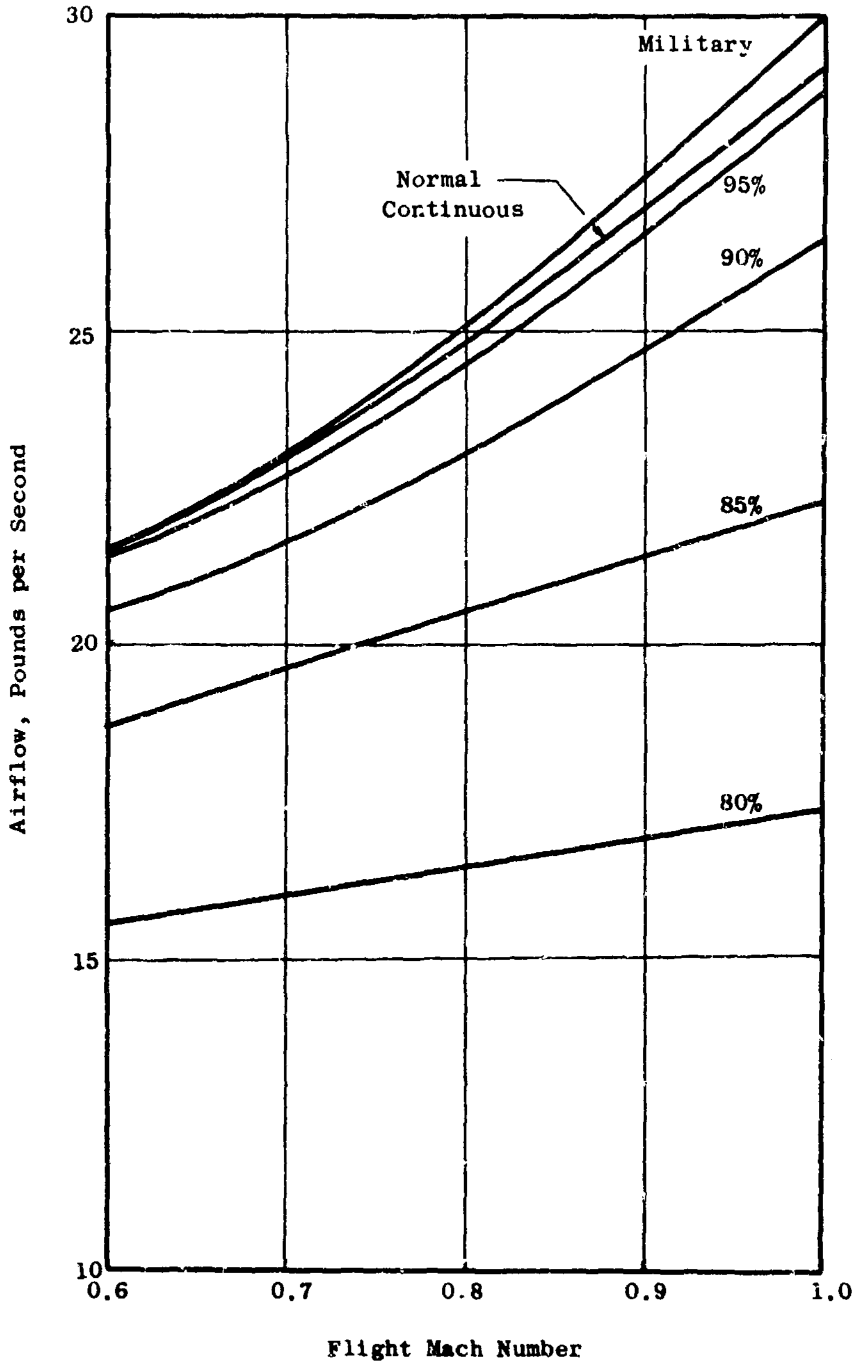


Figure 12. (C) J97/J1B Core Engine Airflow Versus Flight Mach Number at an Altitude of 36,000 Feet. (U)

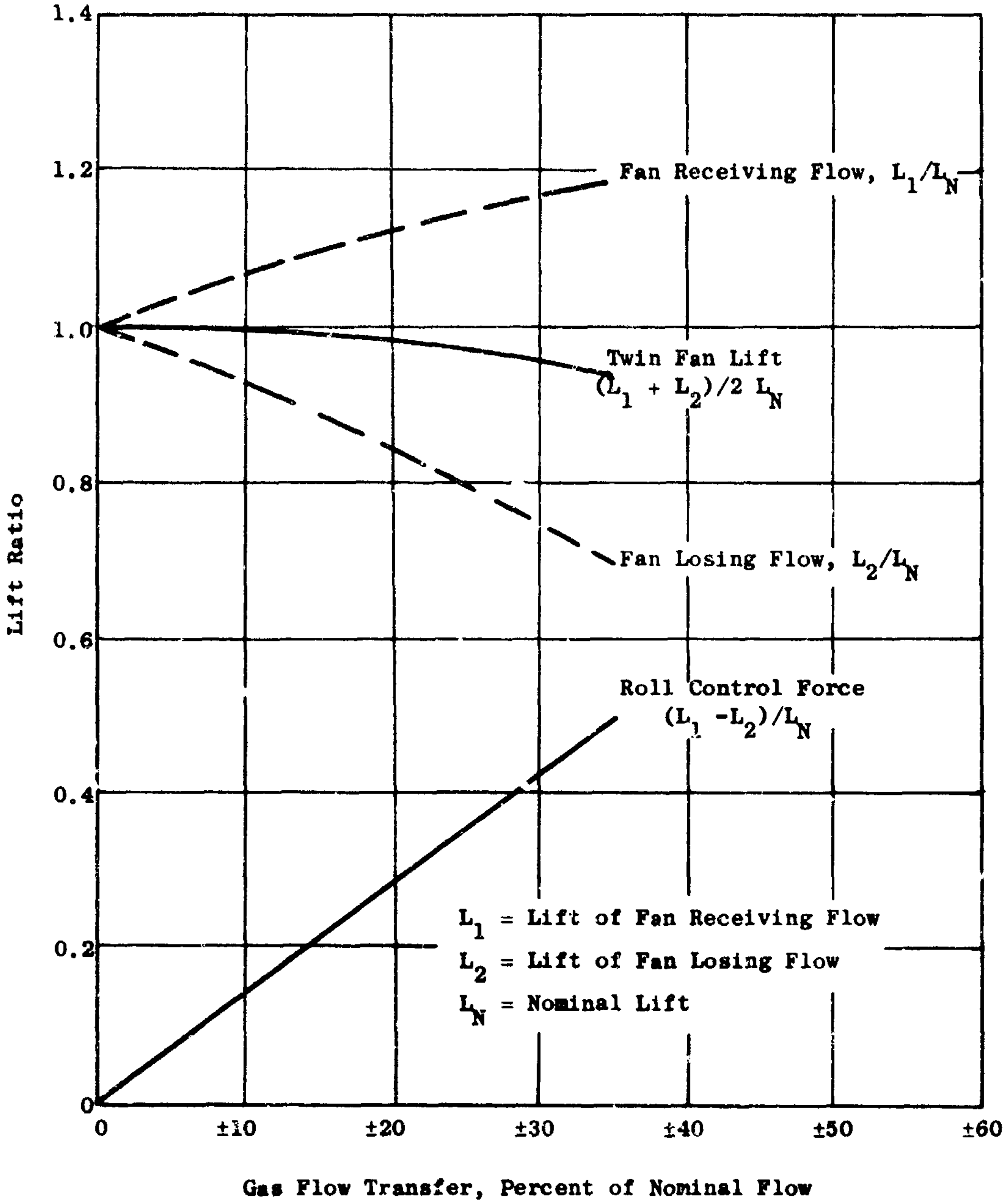


Figure 13. (U) Twin Fan Performance During Power Transfer.

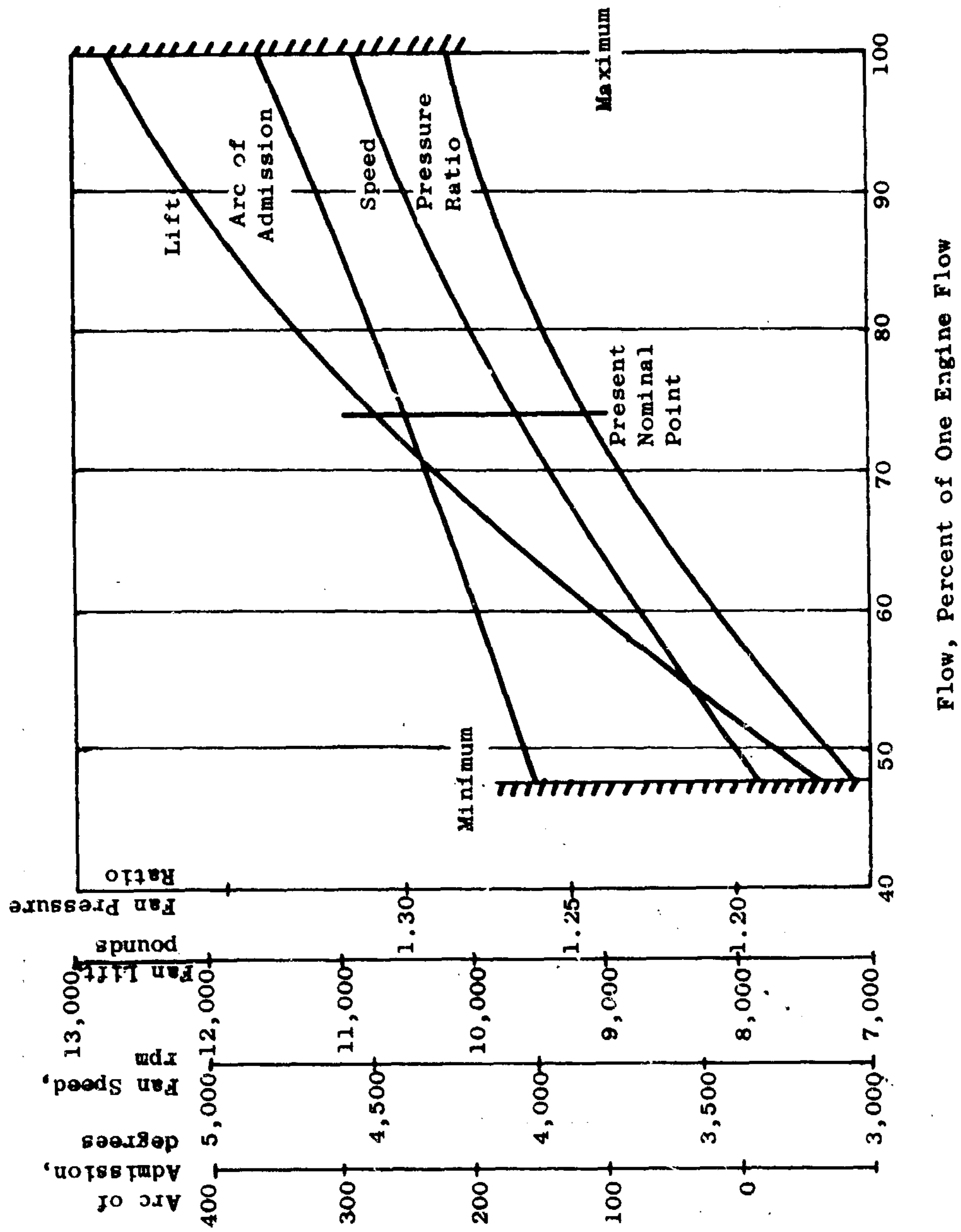


Figure 14. (C) Change in Fan Performance Due To Change in Nominal Operating Point. (U)

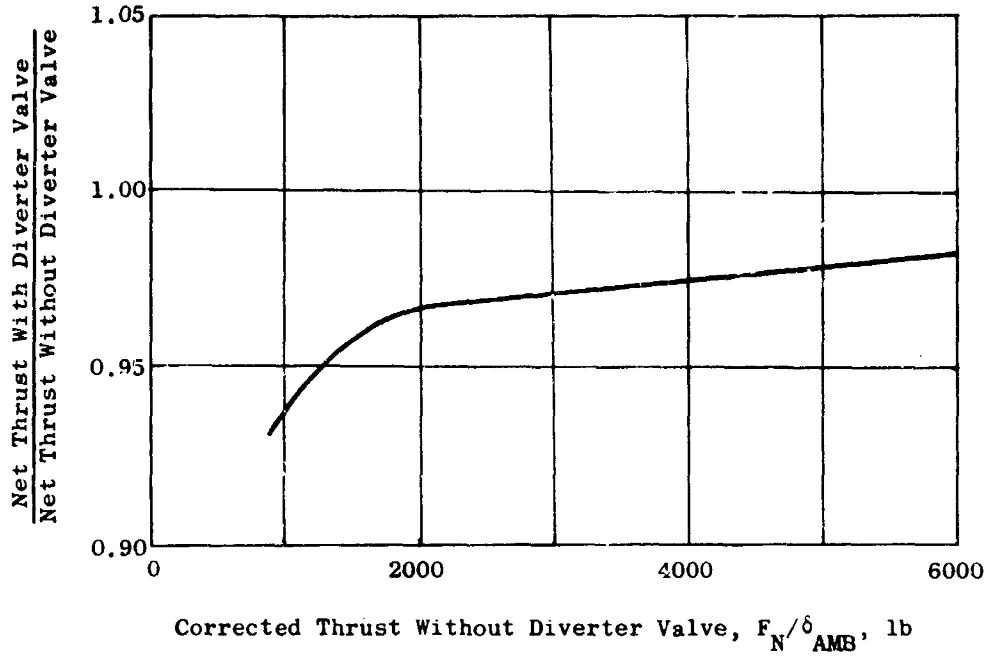


Figure 15. (C) Correction to Cruise Thrust for Diverter Valve. (U)

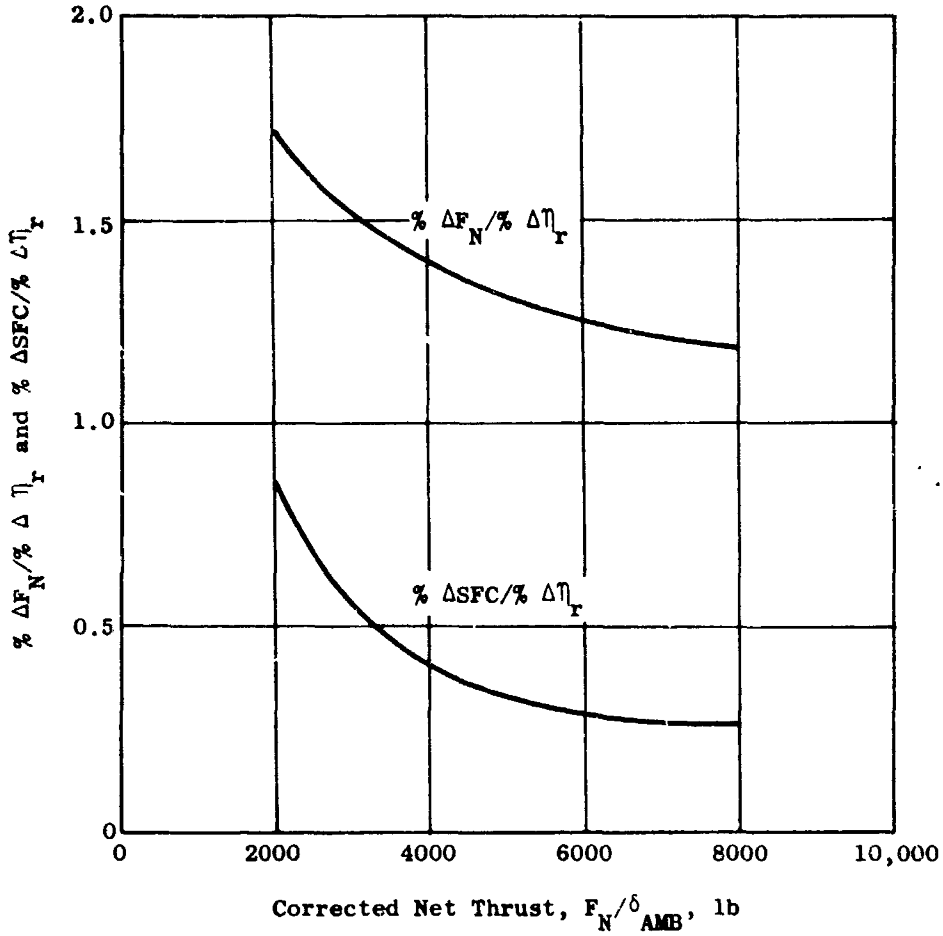


Figure 16. (C) Correction to Cruise Thrust and SFC for Change in Engine Inlet Recovery. (U)

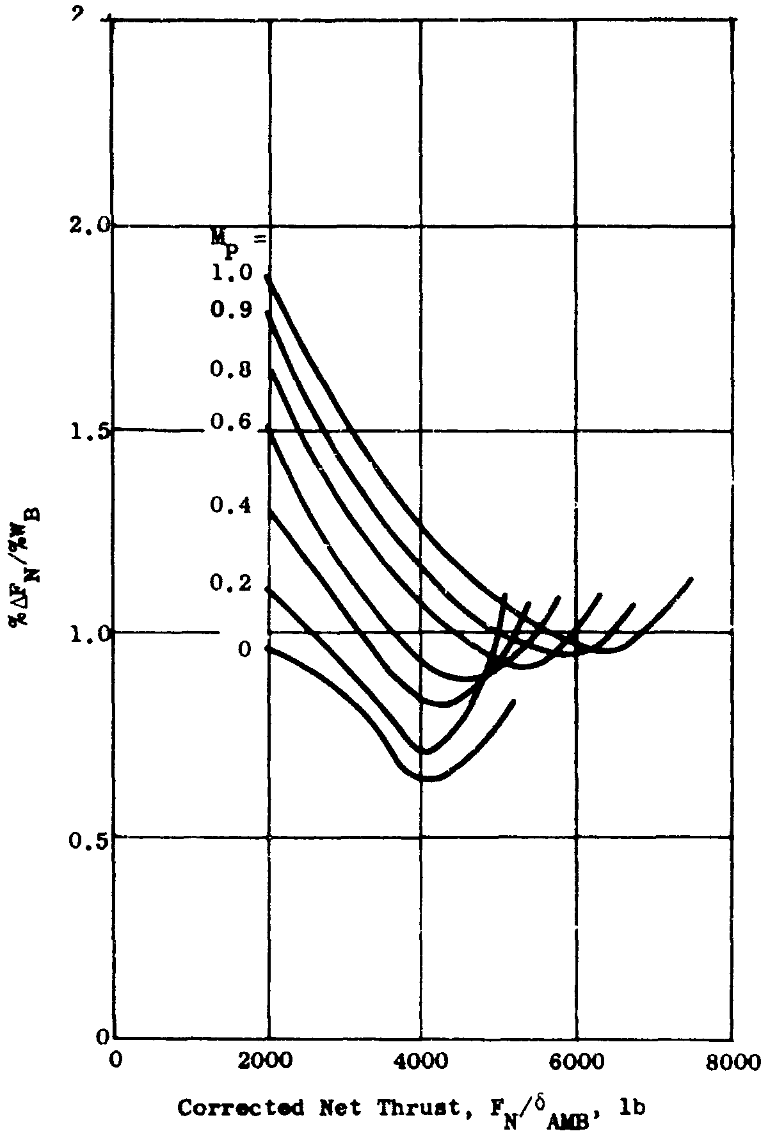


Figure 17. (C) Correction to Cruise Thrust for Engine Compressor Bleed. (U)

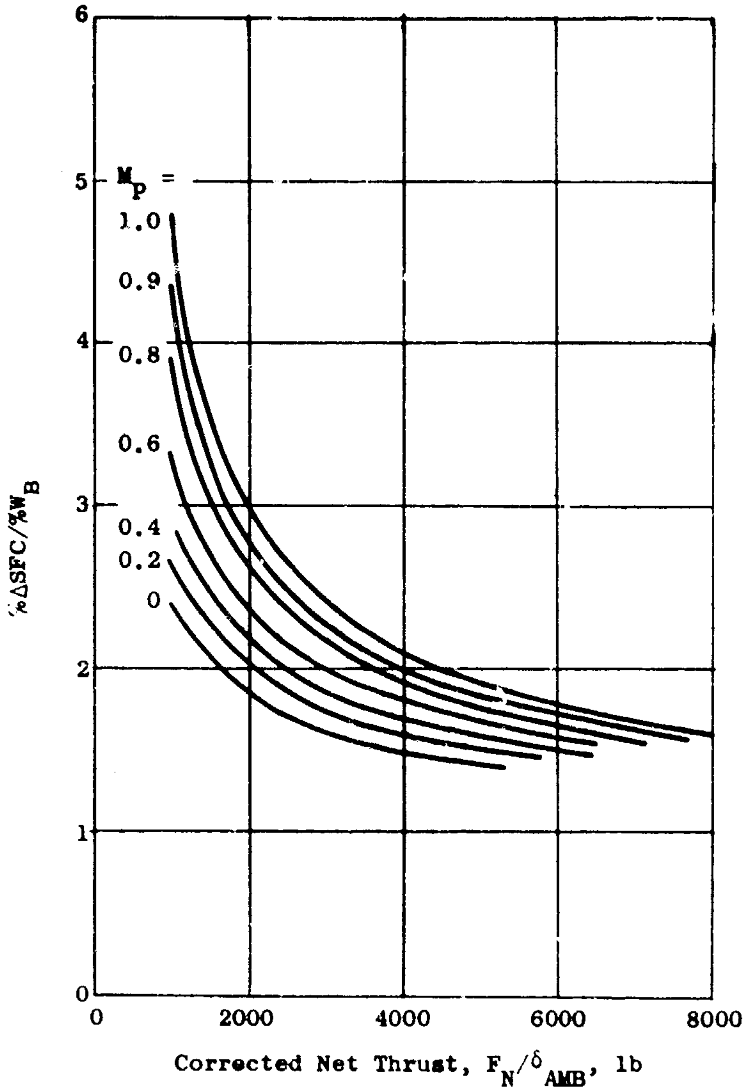


Figure 18. (C) Correction to Cruise Thrust for Engine Compressor Bleed. (U)

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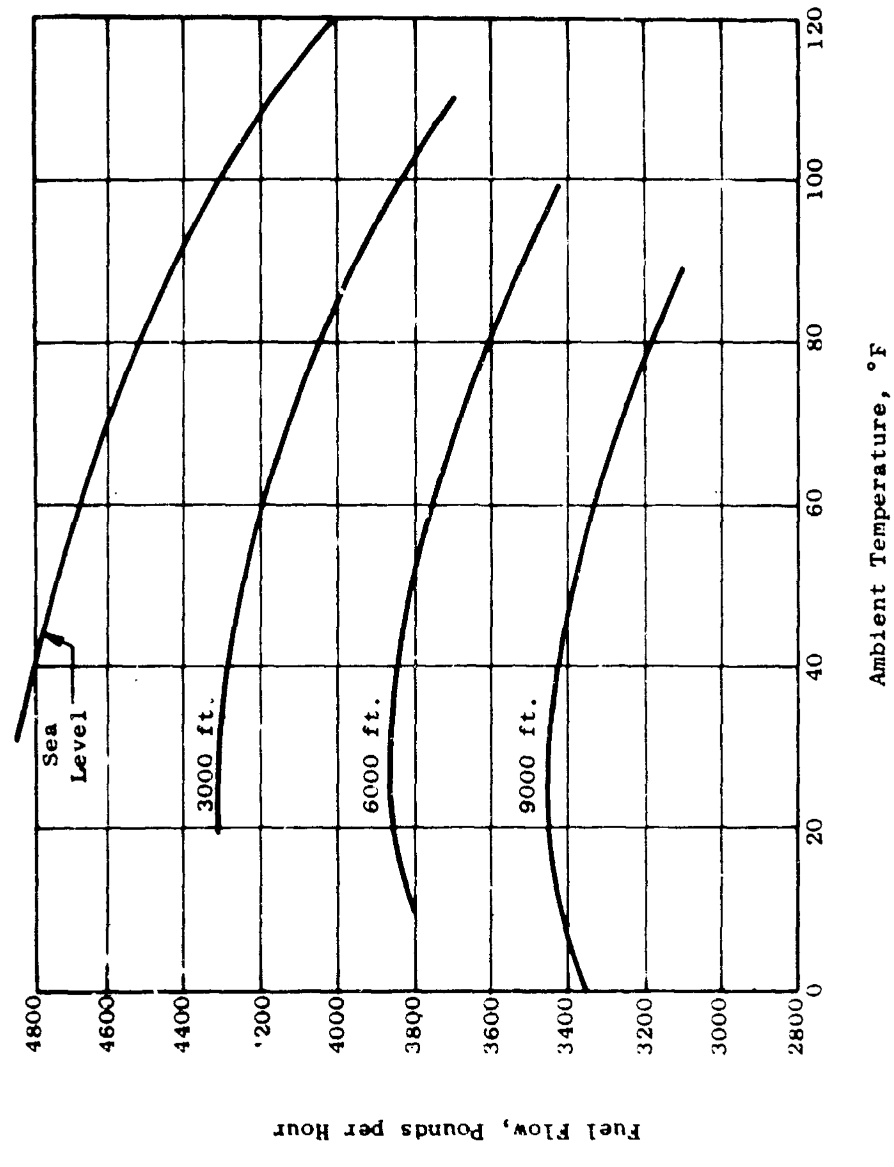

Figure 19. (C) Effect of Ambient Temperature and Altitude on J97/J1B Core Engine Fuel Flow. (U)

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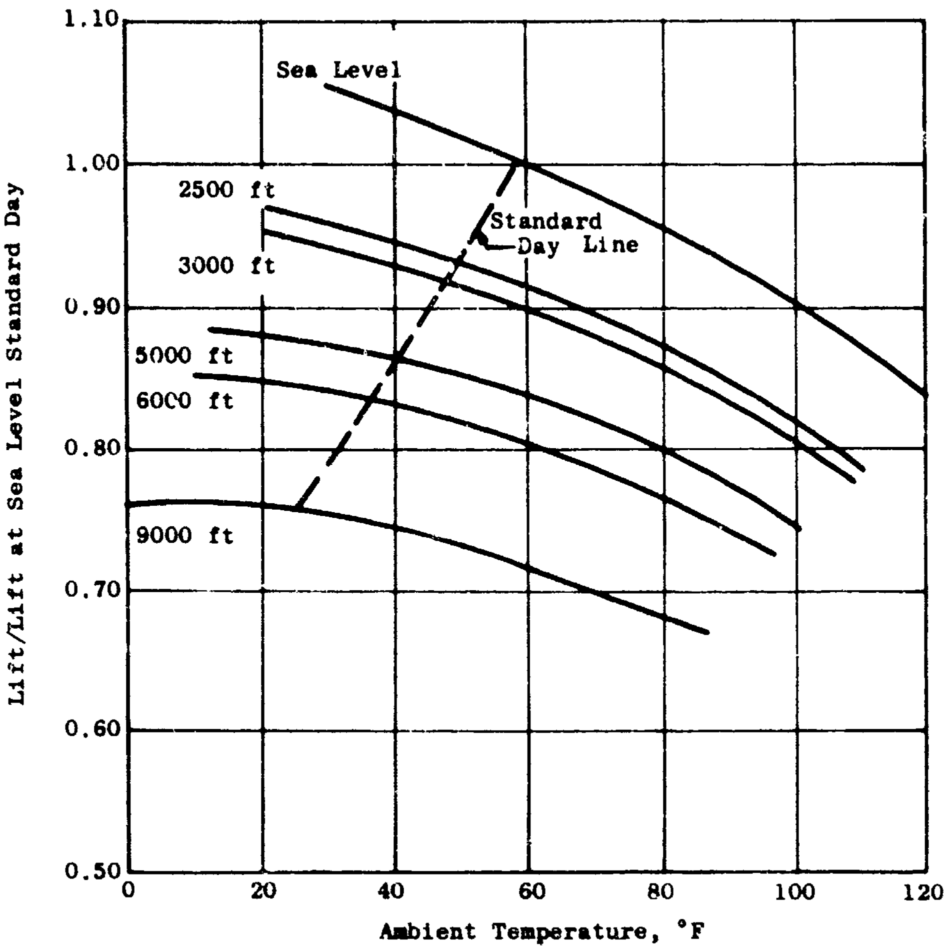


Figure 20. (U) Effect of Ambient Temperature and Altitude on J97/J1B Lift Fan Performance.

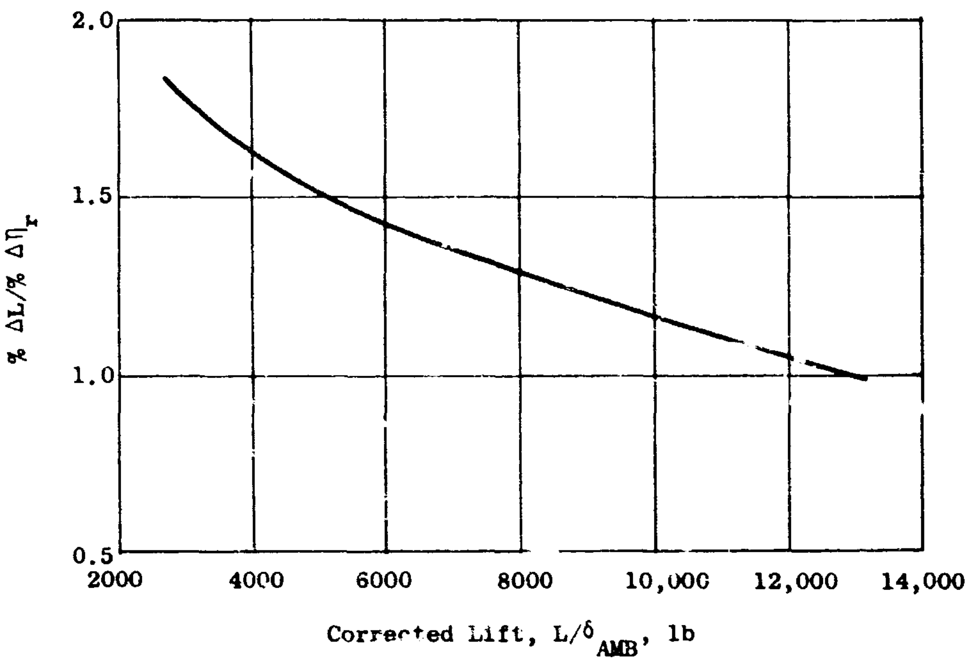


Figure 21. (C) Correction to Fan Lift for Change in Gas Generator Inlet Recovery. (U)

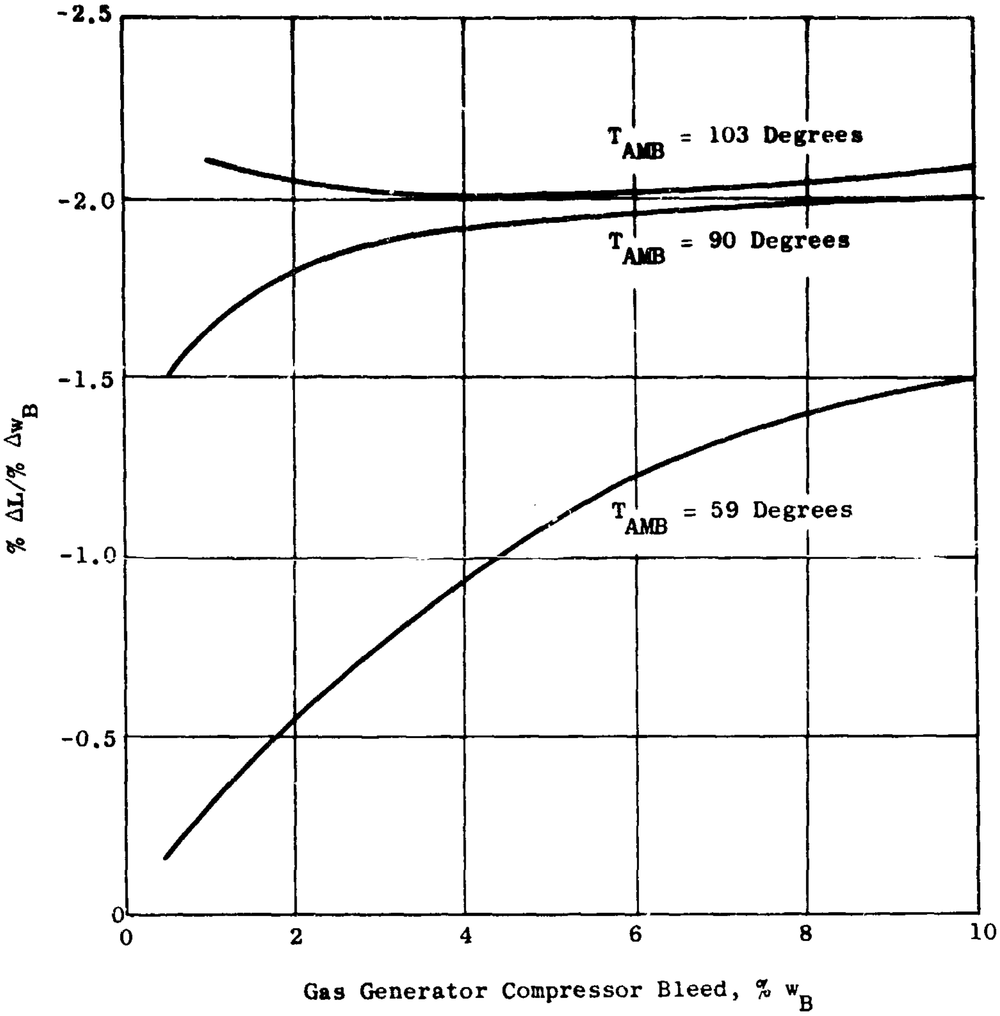


Figure 22. (C) Correction to Fan Lift for Gas Generator Compressor Bleed. (U)

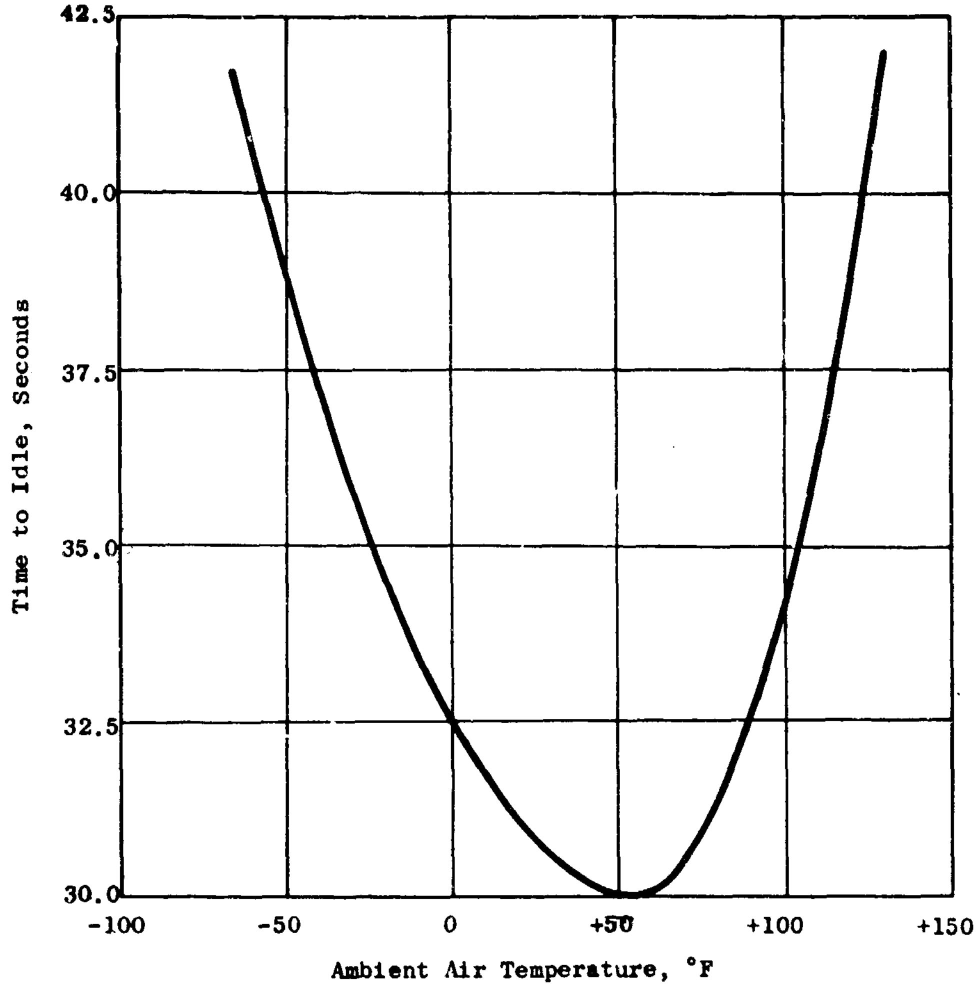


Figure 23. (C) Estimated Engine Starting Limits. (U)

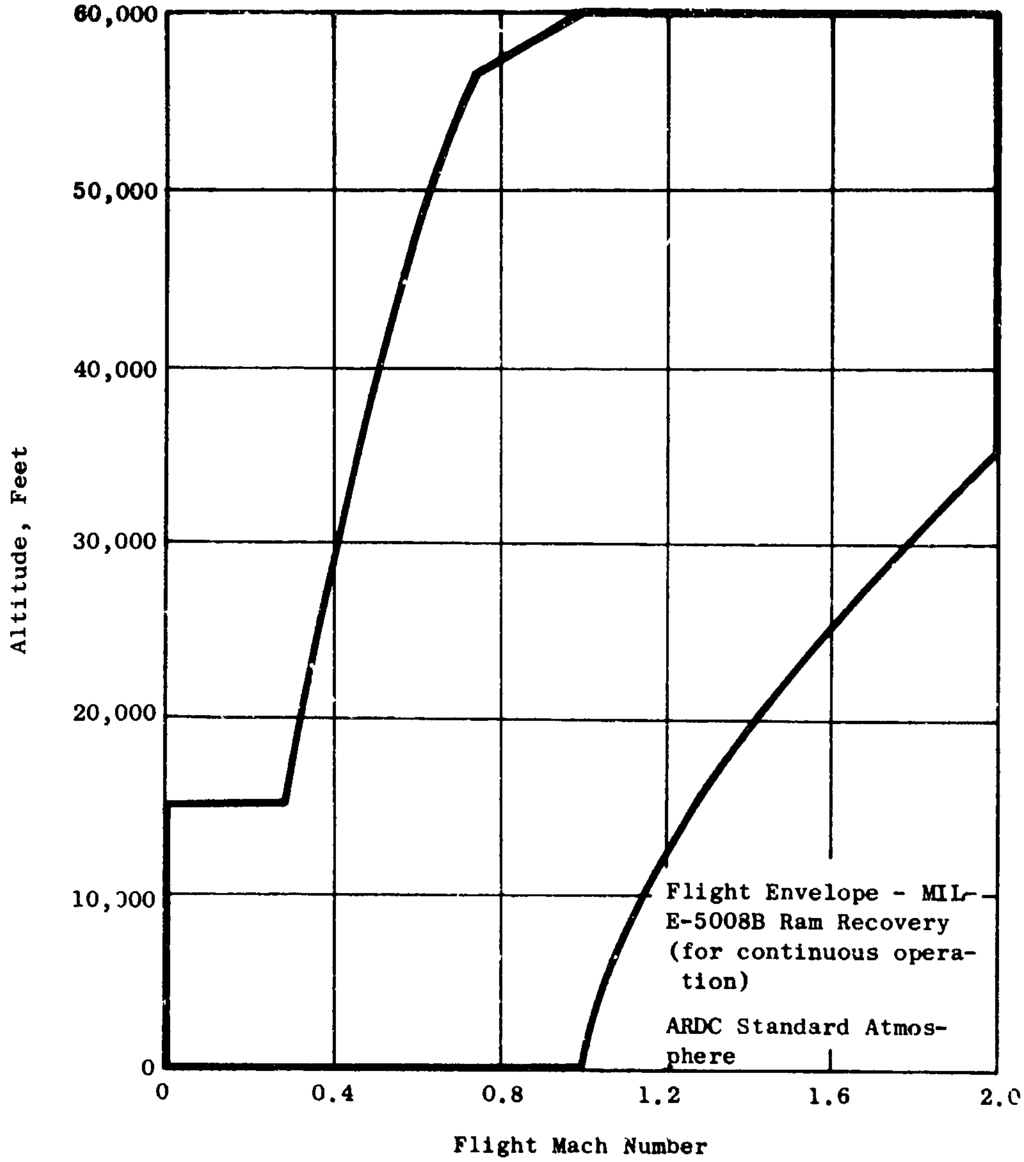


Figure 24. (C) Flight Envelope. (U)

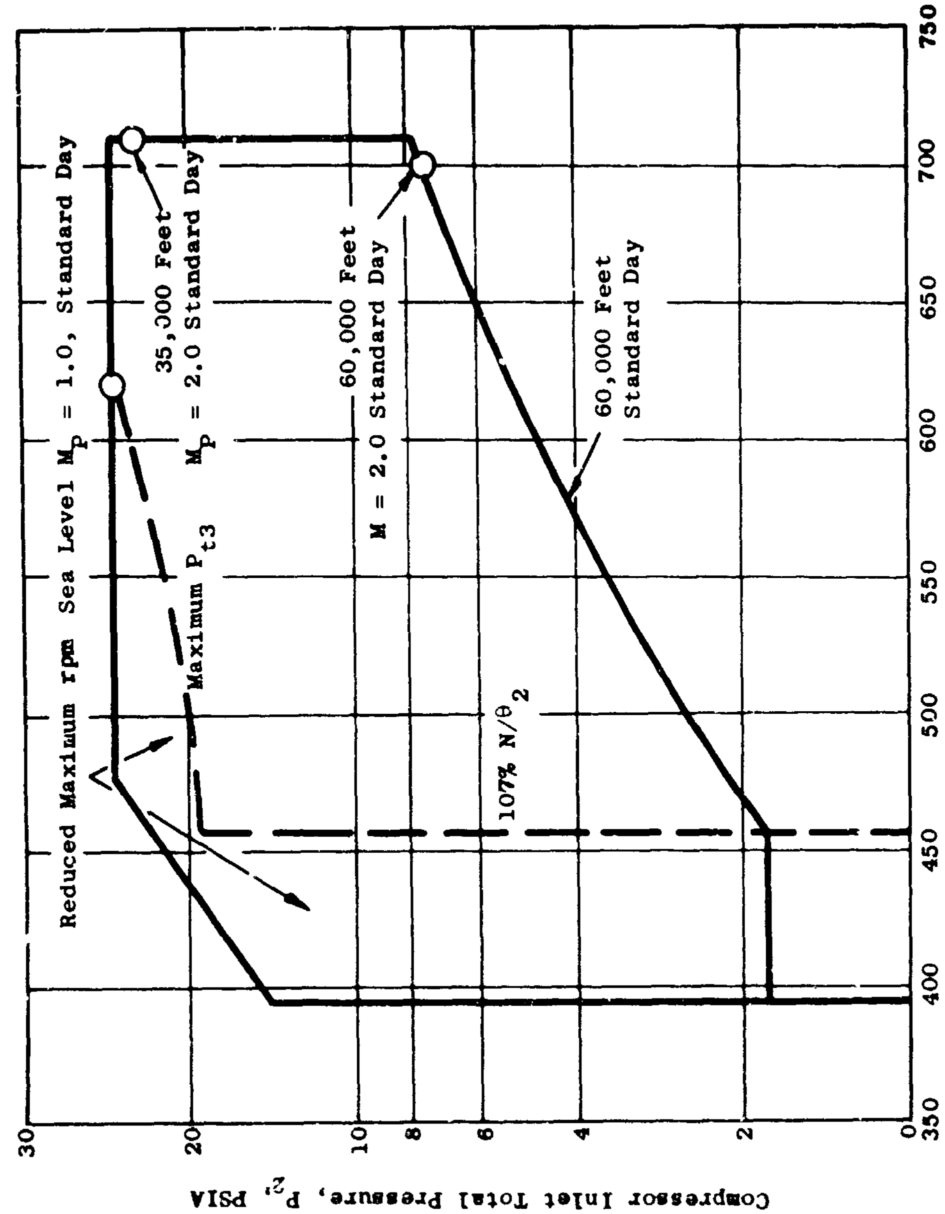


Figure 25. (C) Propulsion System Operating Limits - Turbojet Mode. (U)

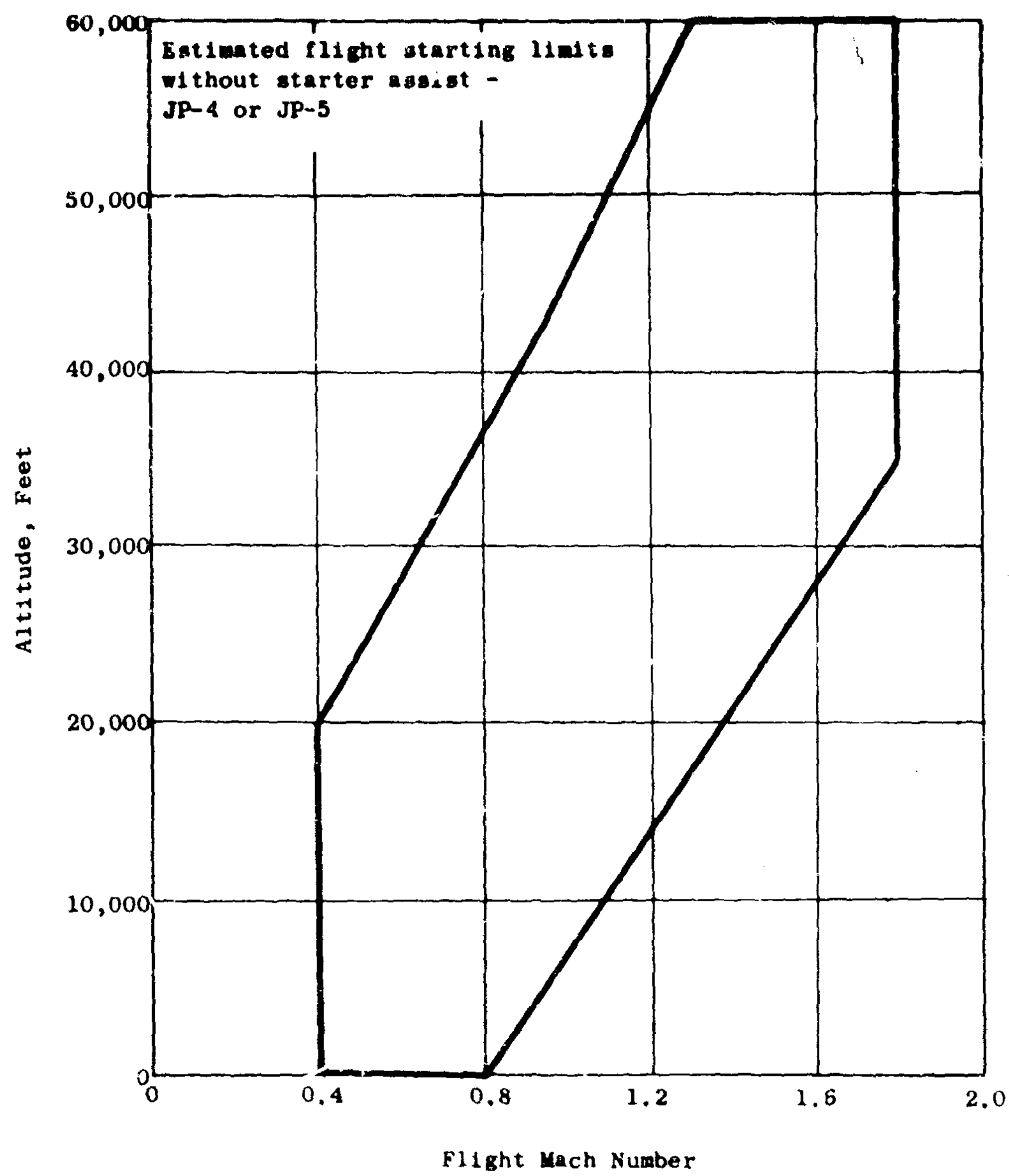


Figure 26. (C) Estimated Flight Starting Limits. (U)

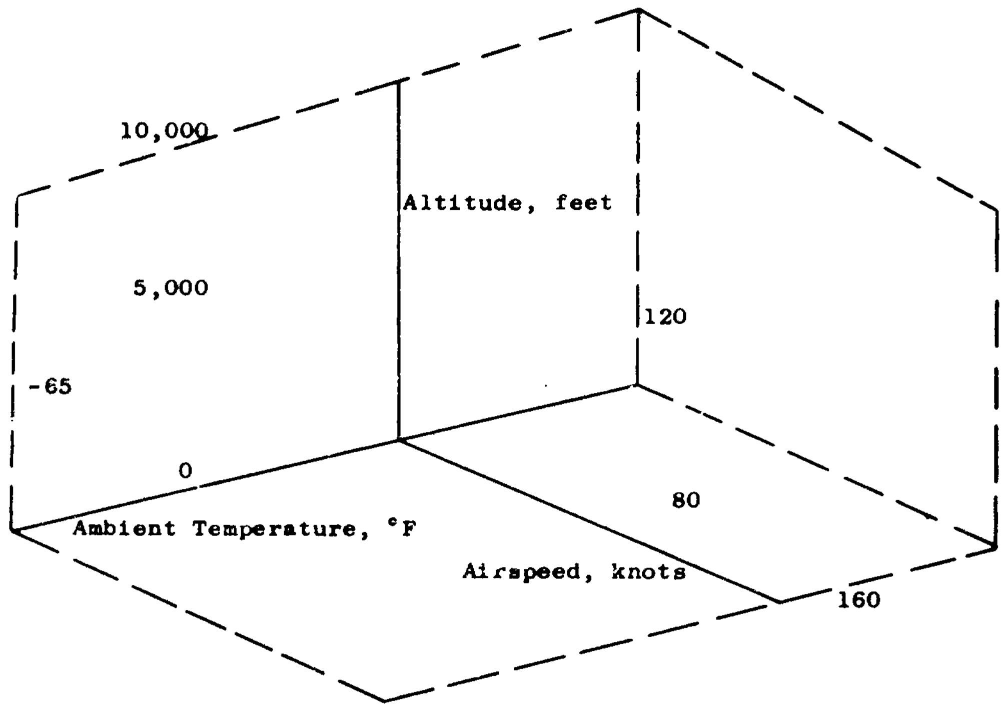


Figure 27. (U) Propulsion System Operating Limits - Lift Mode.

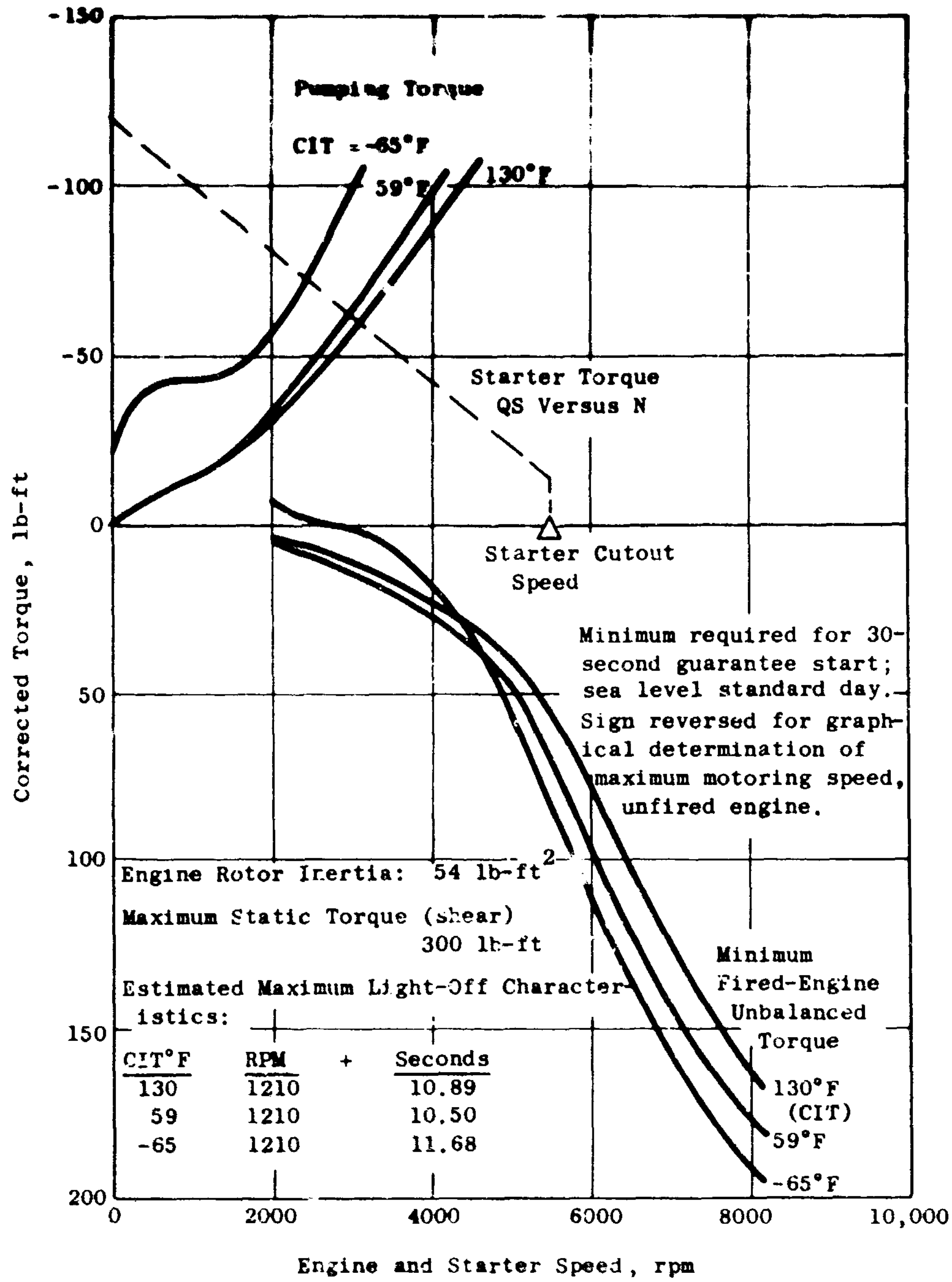
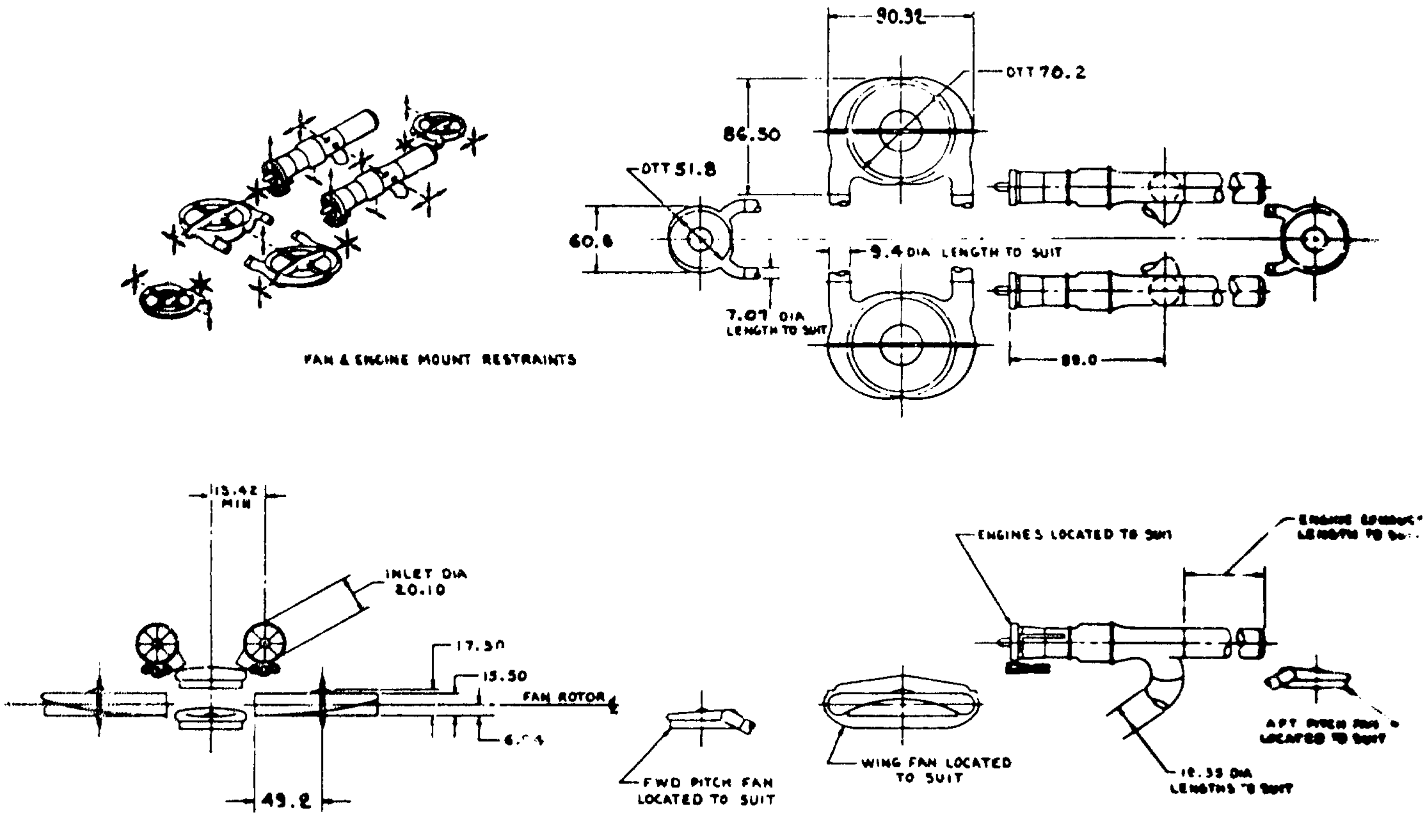


Figure 28. (C) Estimated Starting Torque Characteristics. (U)



<u>Note:</u> All dimensions shown in inches.

Figure 29. (C) System Installation Schematic. (U)

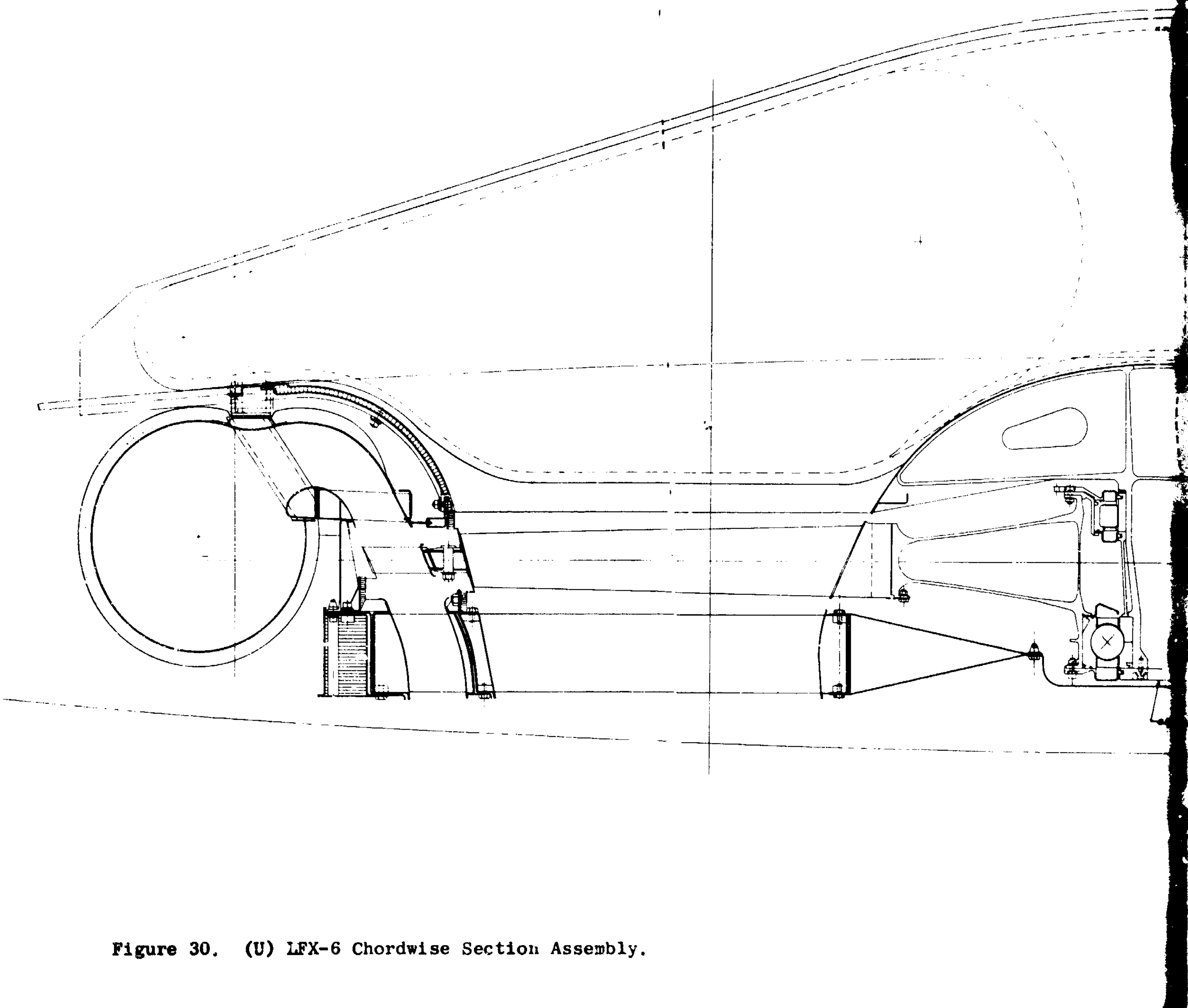
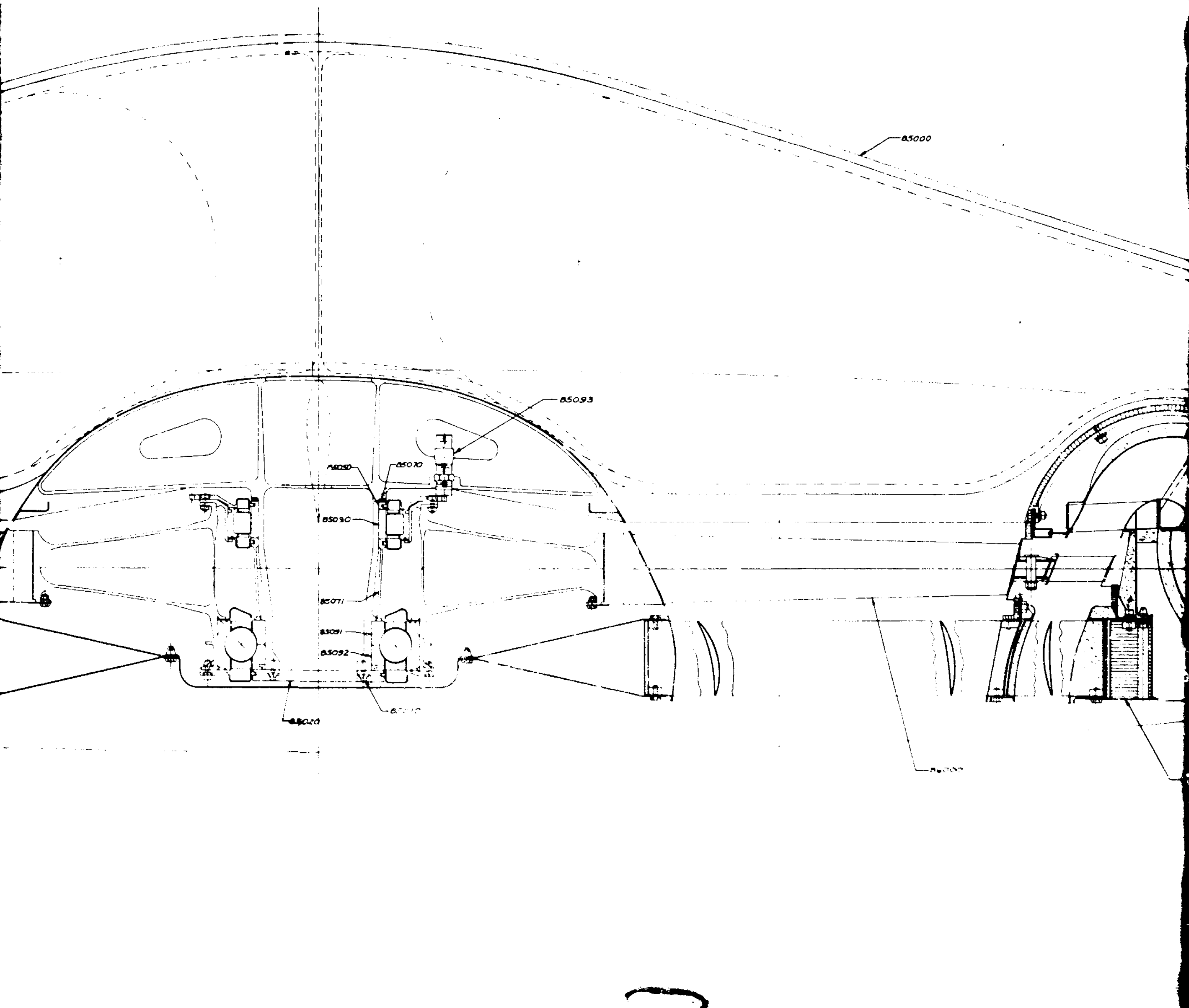


Figure 30. (U) LFX-6 Chordwise Section Assembly.



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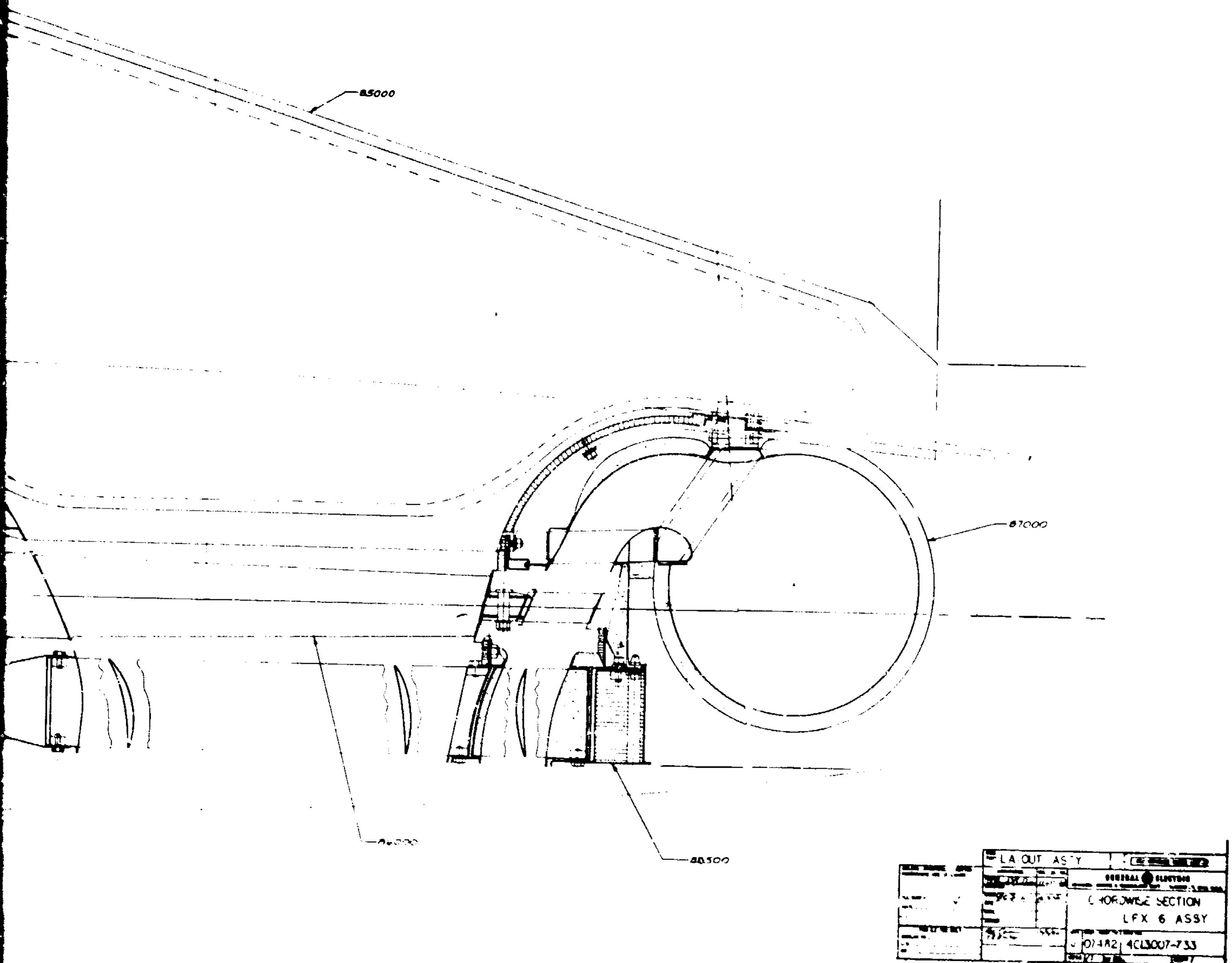
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LAYOUT ASSY
GENERAL ELECTRIC
CHORDWISE SECTION
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3

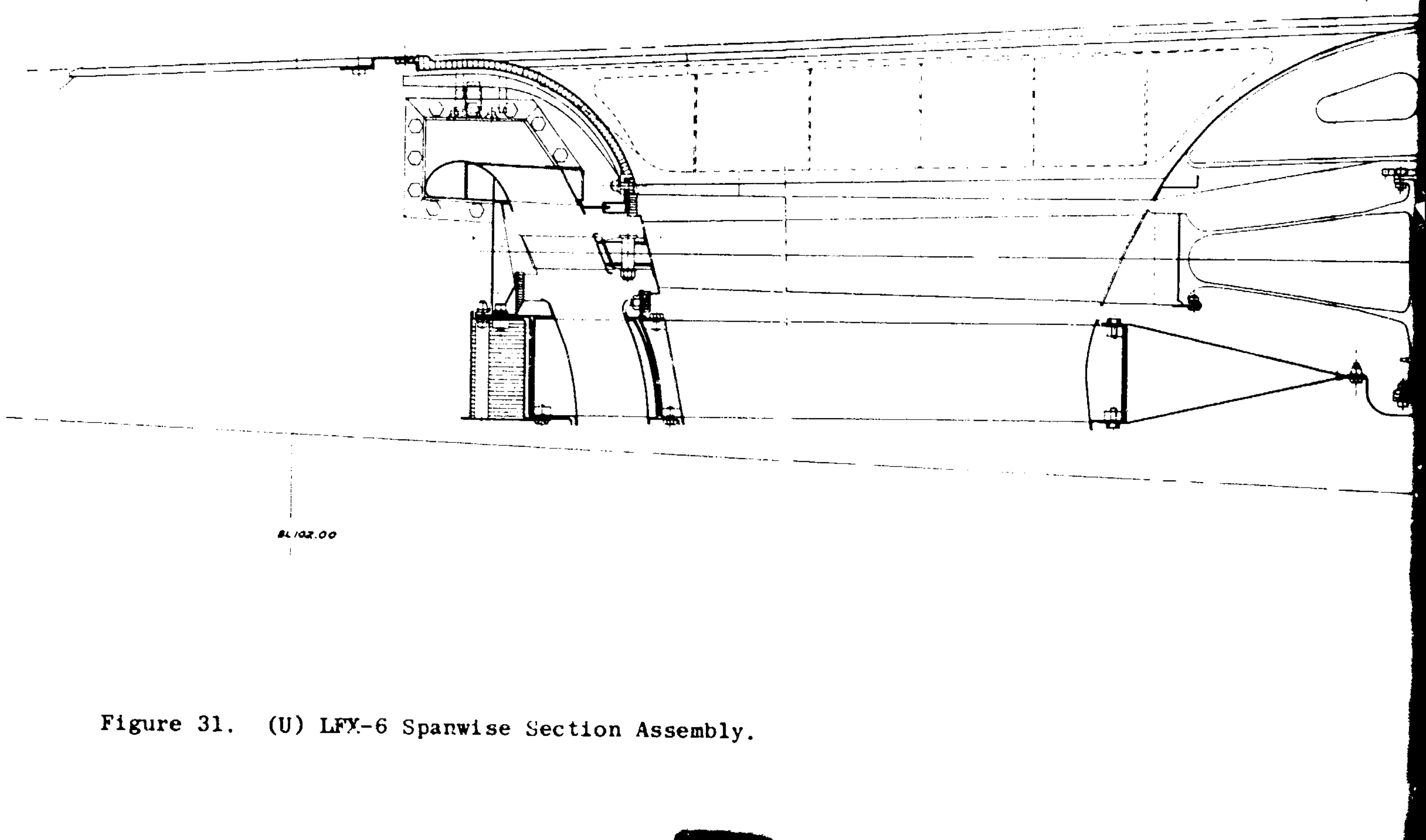
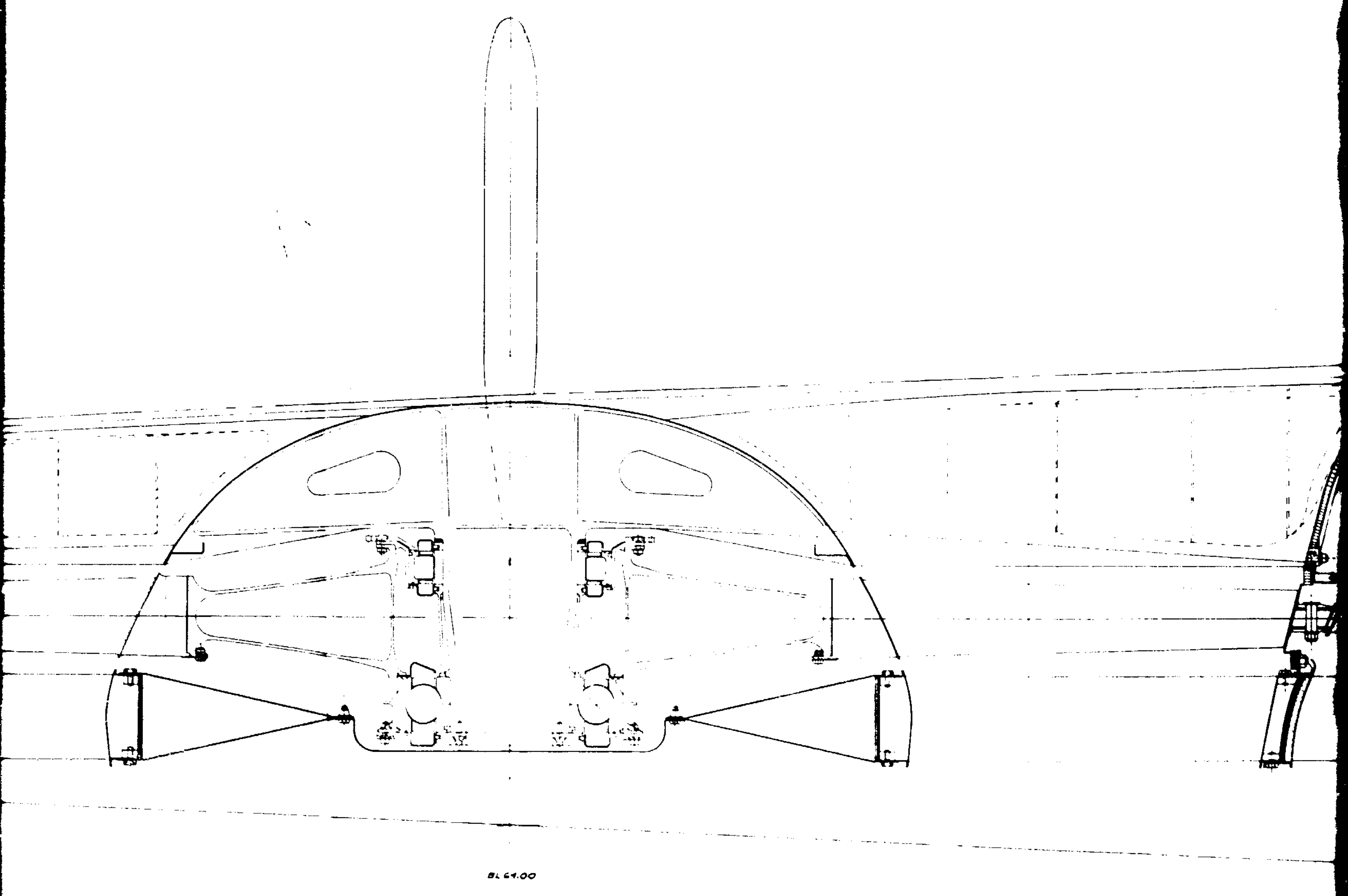


Figure 31. (U) LFX-6 Spanwise Section Assembly.



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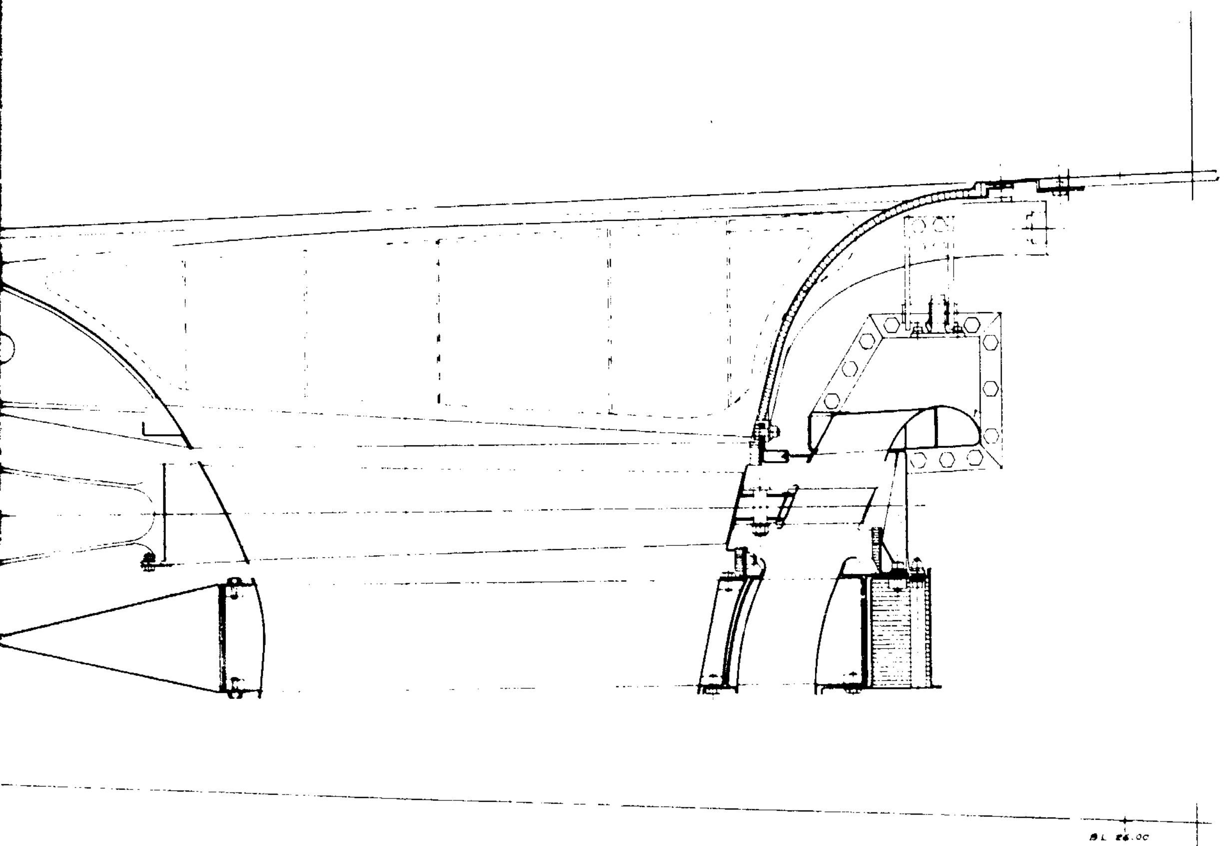


LAYOUT ASSY

GENERAL ELECTRIC

SPANWISE SECTION
LFX-6 ASSY

J	07482	4013007-733

1/1

3

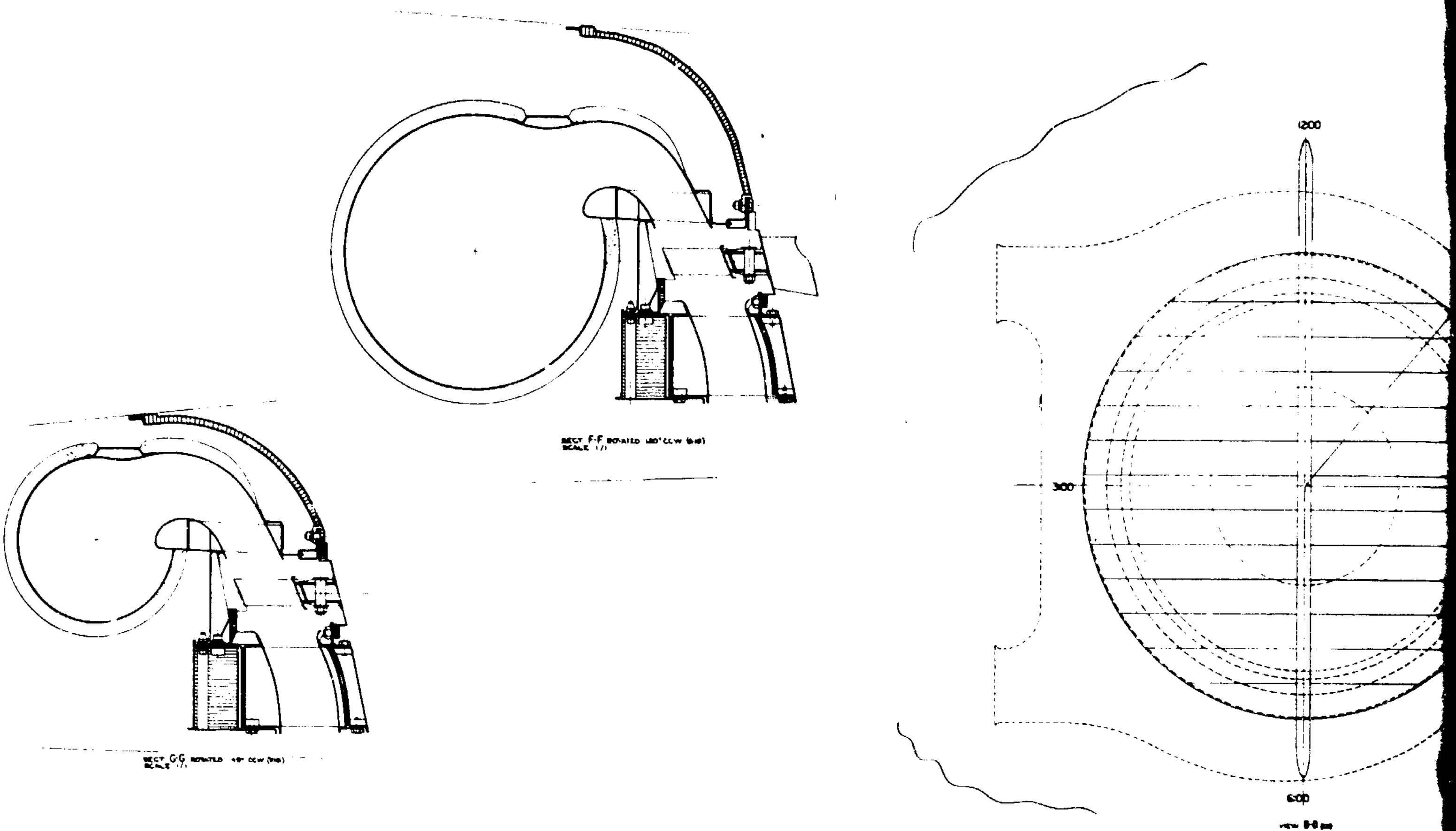
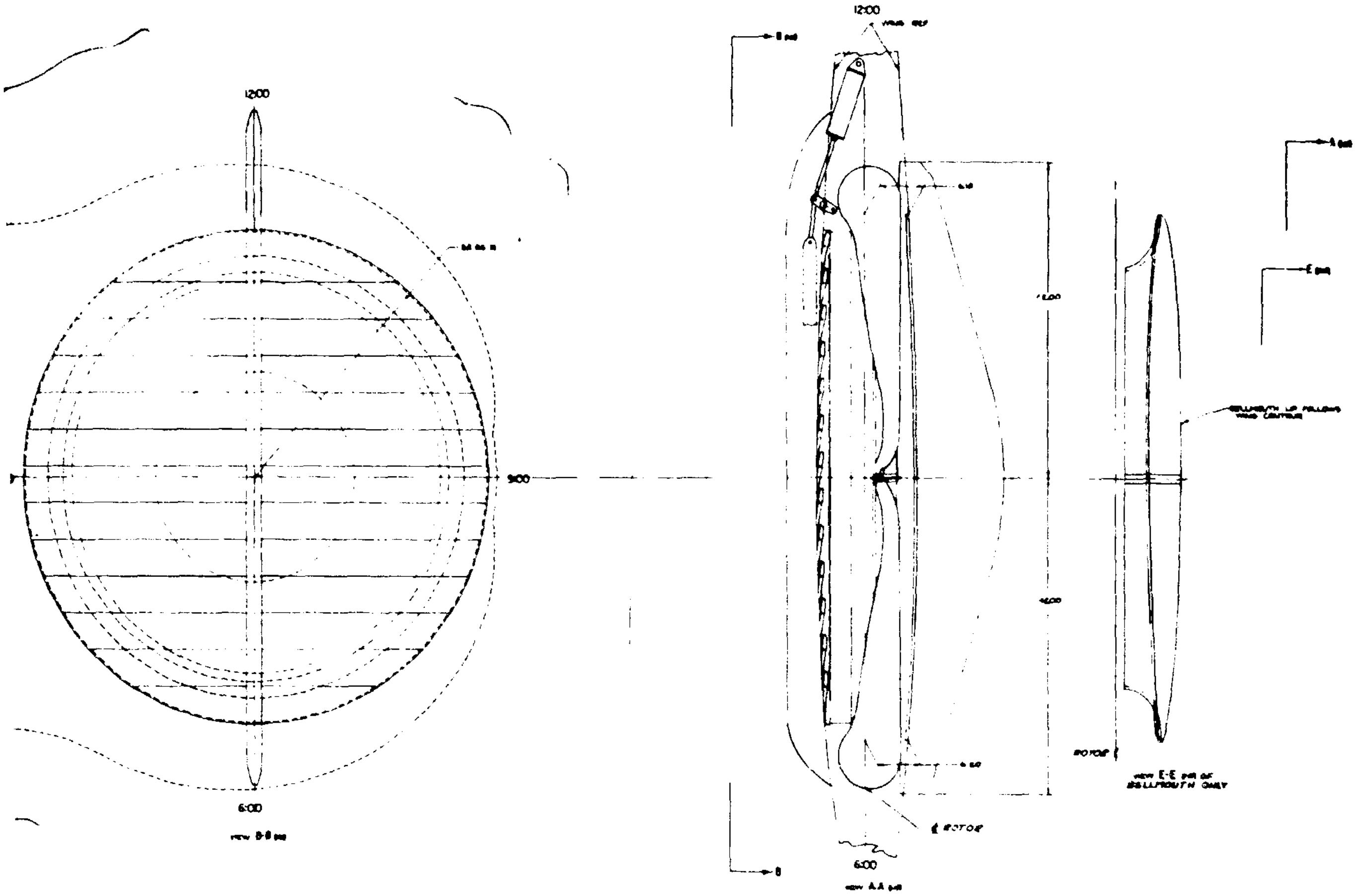


Figure 32. (U) LFX-6 Installation.



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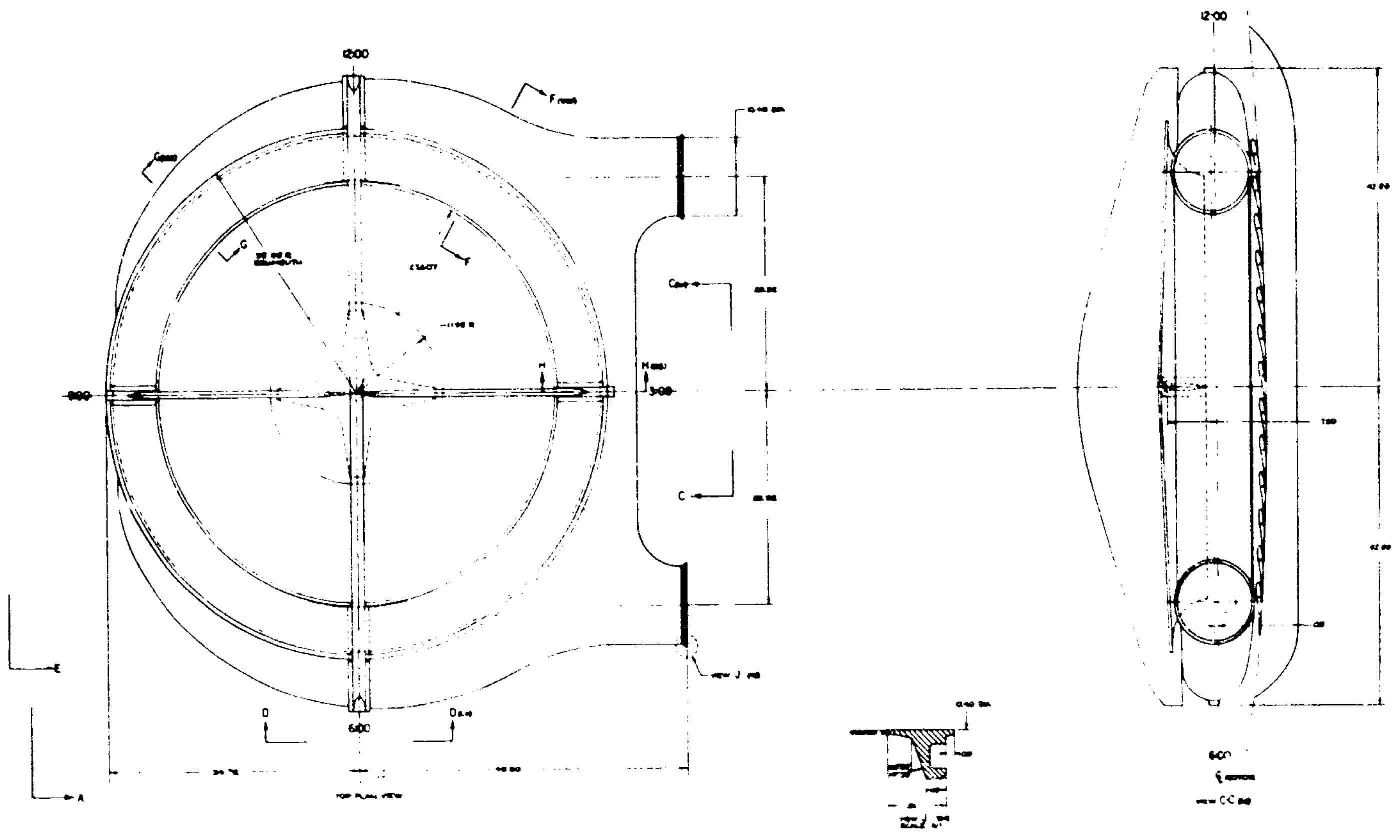
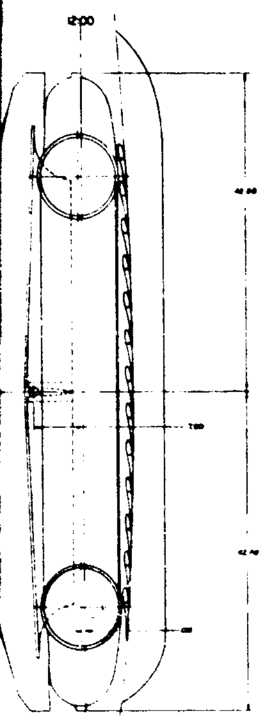
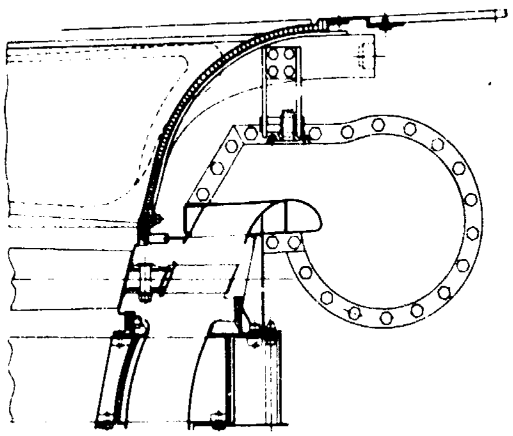


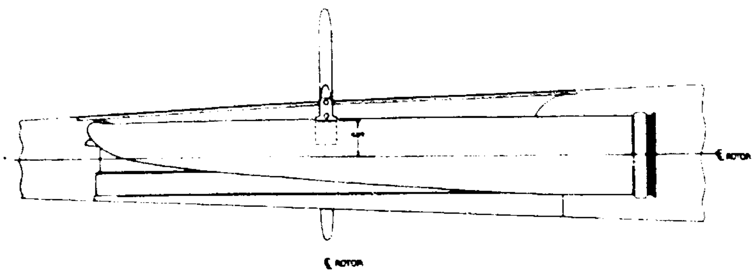
Figure 32 (cont)



VIEW C-C



SECTION H-H
SCALE



VIEW D-D

	STUDY	
		INSTALLATION LFX-6
		J	4013007 739

2

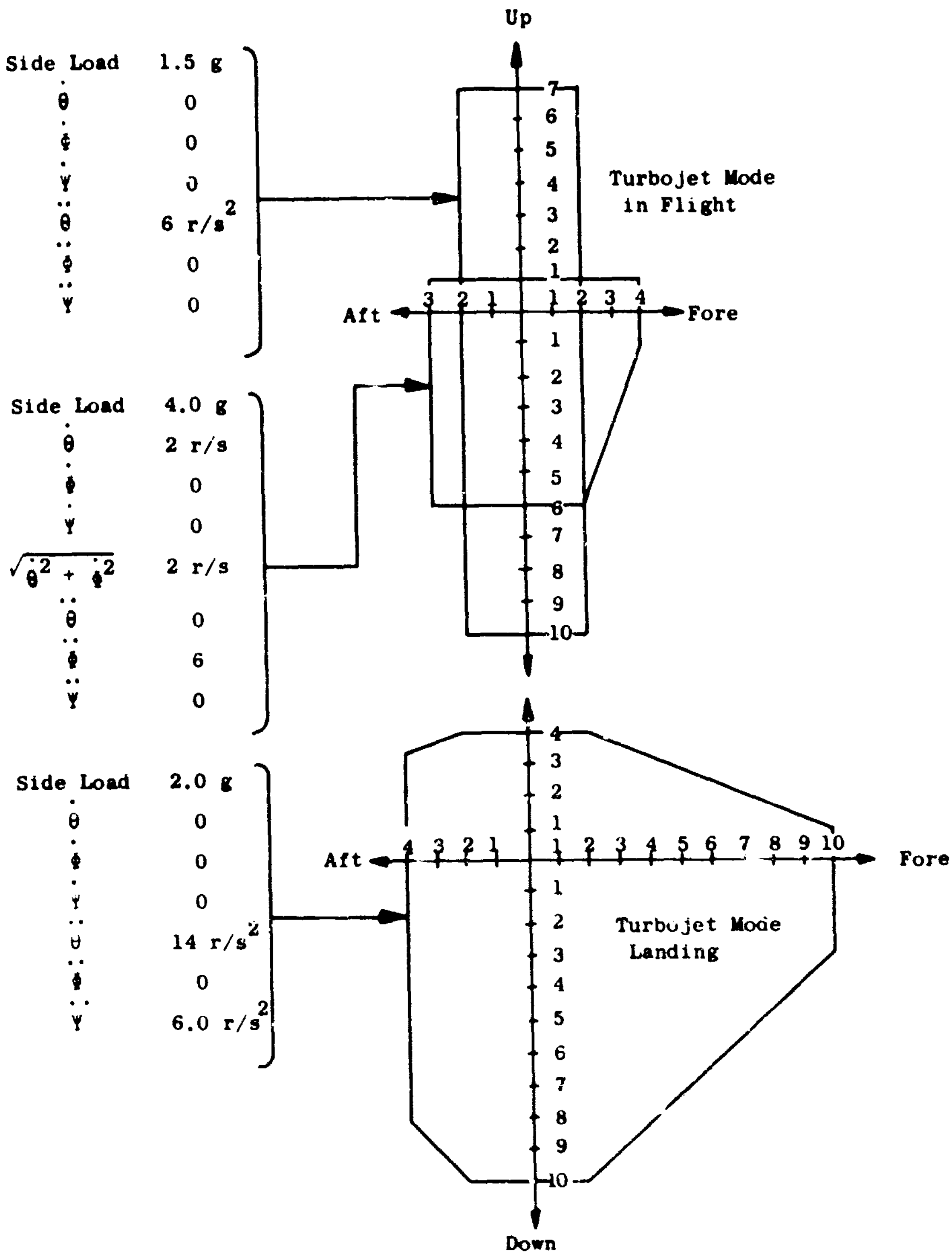


Figure 33. (C) Maneuver Loads - Turbojet Mode. (U)

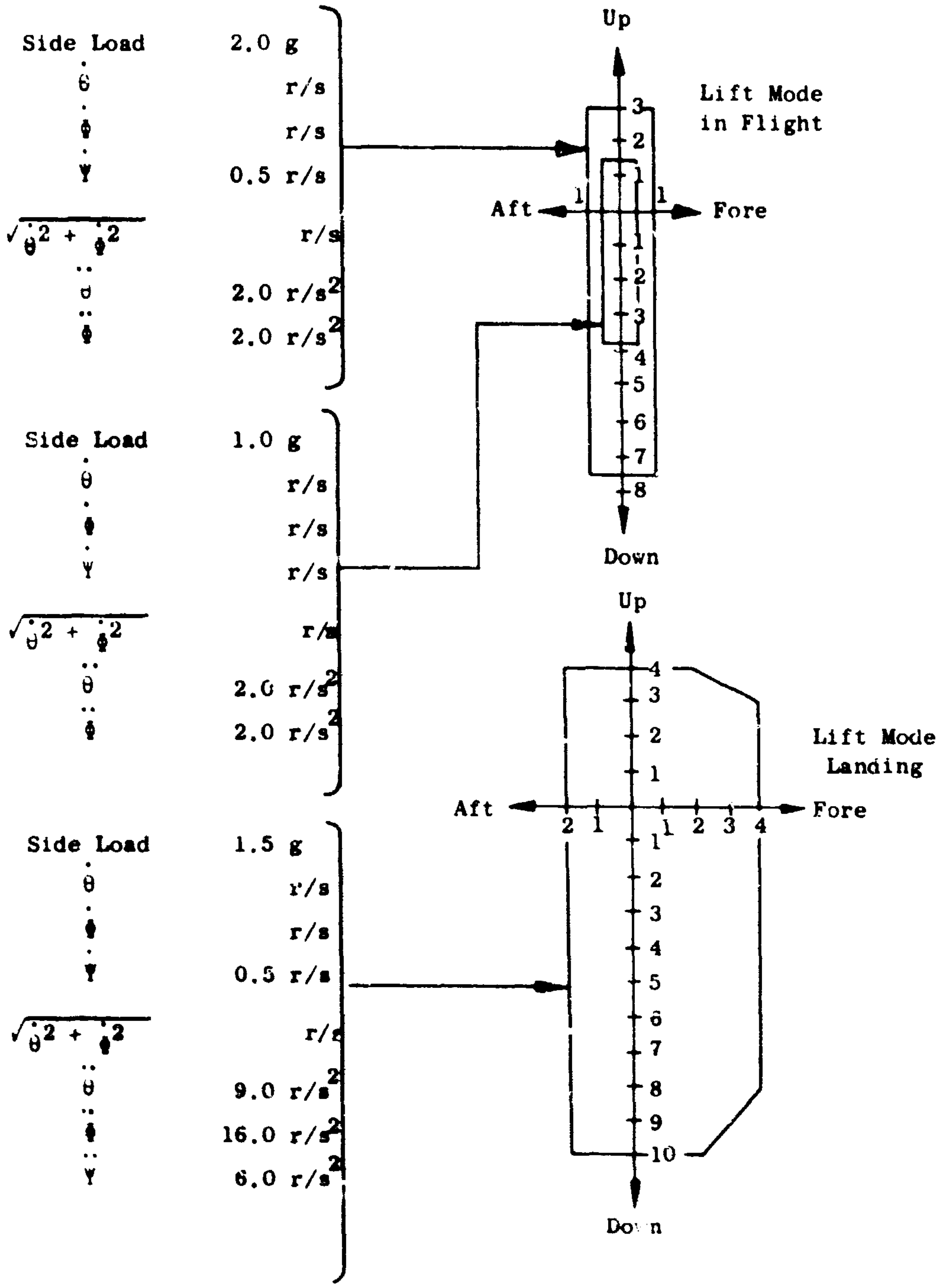


Figure 54. (U) Maneuver Loads - Lift Mode.

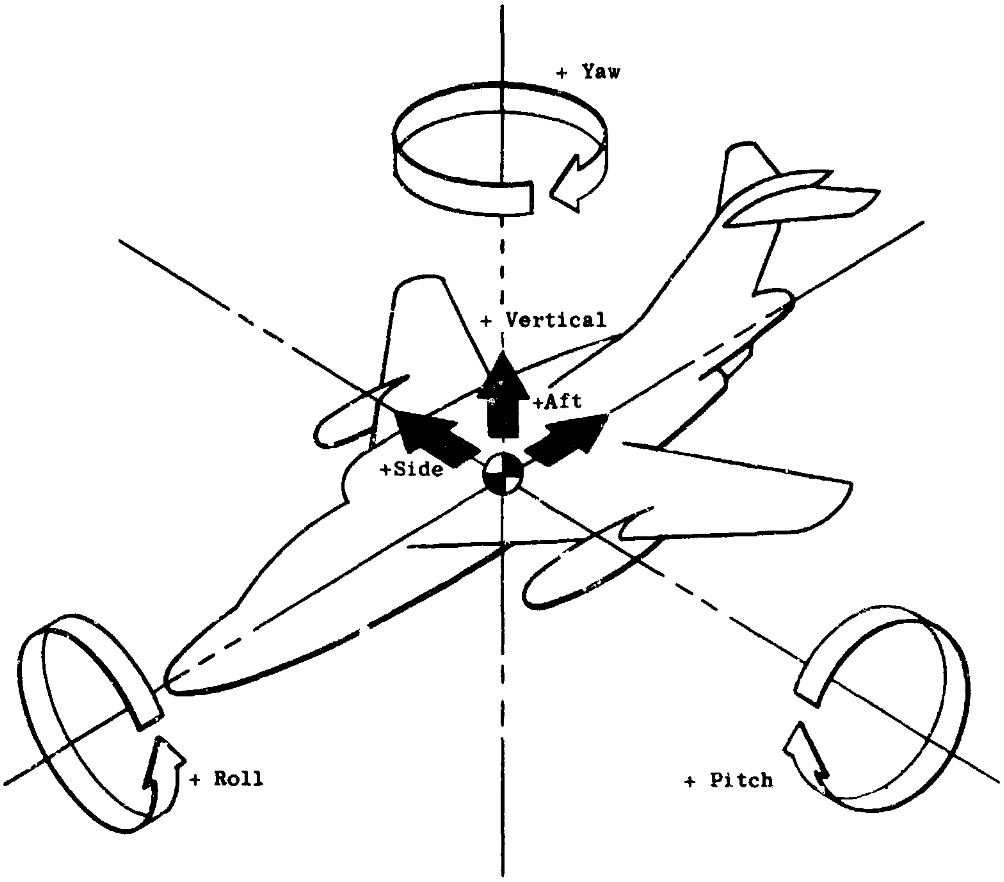


Figure 35. (U) Sign Convention for Aircraft Motion and Propulsion System Mount Loads.

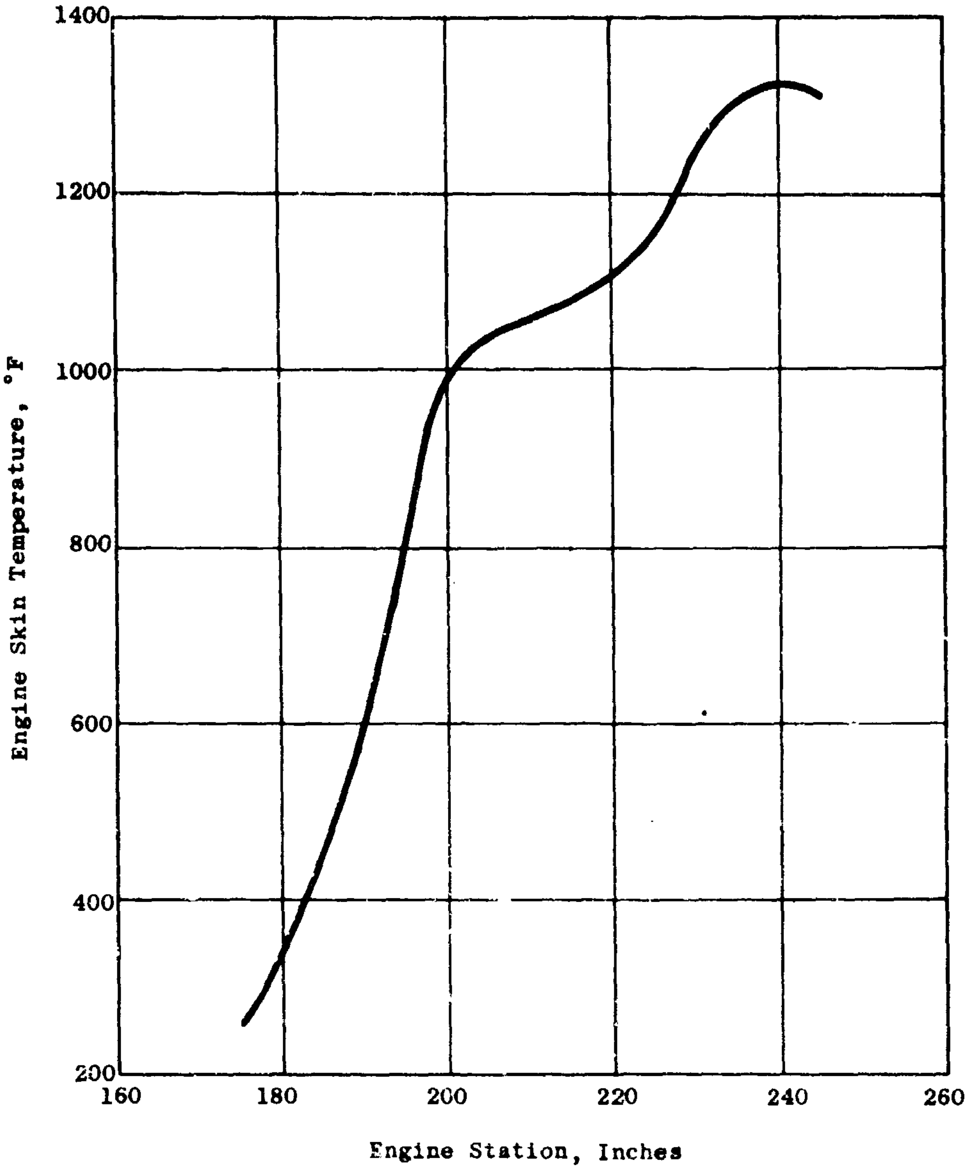


Figure 36. (C) Estimated Maximum Allowable Turbojet Operating Skin Temperatures. (U)

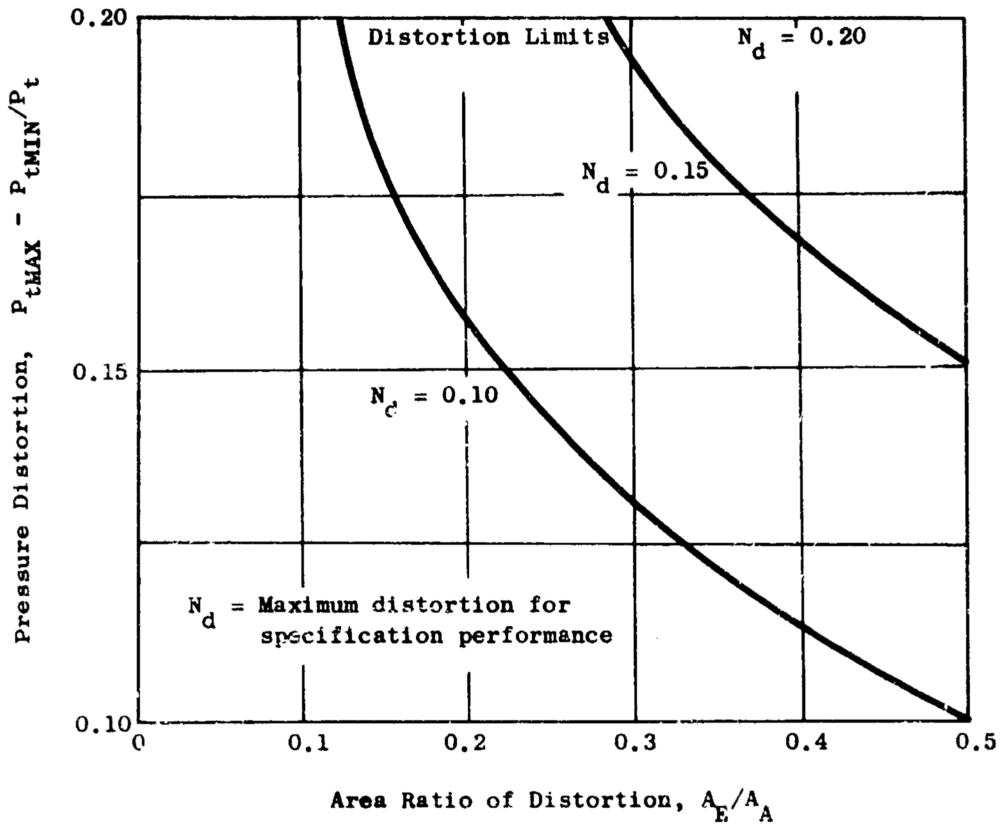


Figure 37. (C) Engine Inlet Distortion Limits. (U)

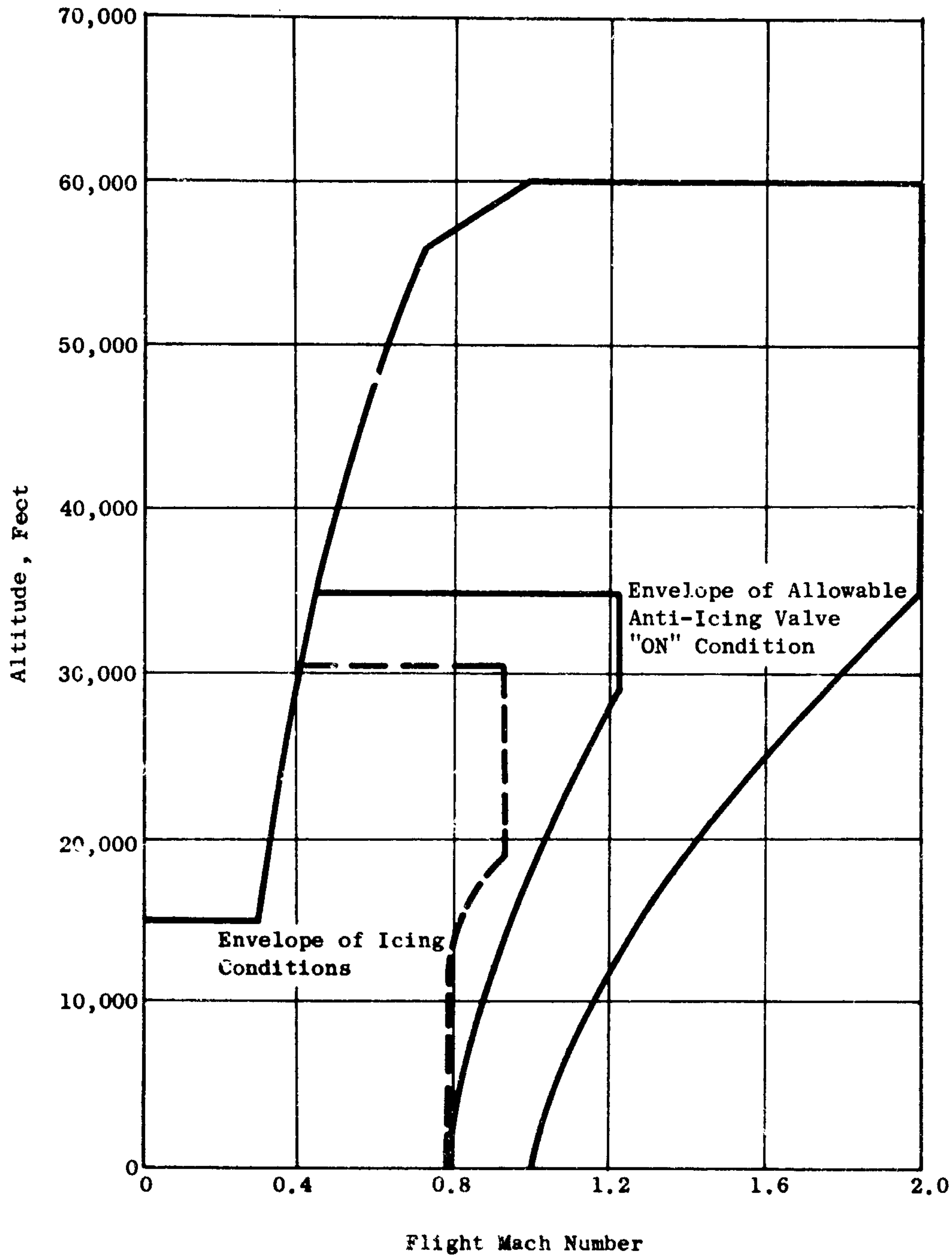


Figure 38. (C) Anti-Icing Flight Requirements Envelope. (U)

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13. ABSTRACT

(U) A Preliminary Design Specification for an advanced-technology lift fan V/STOL propulsion system is presented. Requirements for mechanical and aerodynamic design, performance and installation are given. Design requirements are based on generalized aircraft installation requirements for a class of aircraft suitable to various mobility concepts.

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14. KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
Design Specification						
Lift Fan Demonstrator						
Tip-Mounted Turbine						
Variable-Area Scroll						
LFX						
Propulsion System						

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